POWER PLANT ENGINEERING

Established Over 34 Years

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Contents of this Issue

	Page
New Plant Built Out of Profits of Old at Independence, Mo.	966
Novel Pump Arrangement Shows Savings. By Arthur McCutchan	972
Combined Industrial and Public Utility Power Plants. By W. F. Ryan	973
Graphic Comparison of Fuel Costs. By George W. Heald	975
Stack Sprays for Fly Ash Recovery. By J. W. MacKenzie	977
Two 11,700-Hp. Diesel Engines Carry Peak Loads. By F. Johnstone Taylor	979
Improved Circuits for Feeder Voltage Regulator	981
Automatic Control of Hydroelectric Stations by the All Relay System—III. By E. H. Stivender	982
Electricity—What It Is and How It Acts. By A. W. Kramer	986
Is the Power House Part of Your Plant? By K. Rankin	989
Waterville—Highest Head Hydroelectric Plant in the East	991
Present Status of District Heating. By J. H. Walker and A. R. Mumford	994
Heat Storage for Four Hundred Million B.t.u.	996
Roller-Log Desk Assures Clean Record Sheet	997
Noel & Co. Installs Ice Plant No. 2 in Nashville	998
Hot Ice	998
V-Belt Transmission for Power Distribution. By Walter A. Meyer	999
Socketing of Steel Wire Rope Slings	1000
Electric Motor Control. By E. G. Peterson	1001
Lubrication Bettered by Oil Reclamation. By Ralph L. Young	1003
Modern Wood Waste Collection. By C. N. Deverall	1006
Fifth Midwest Power Engineering Conference at Chicago Feb. 10—13, 1931	1009
Letters Direct from the Plant: Selecting Stokers for New England Fuel. Interesting Experiences in Repairing Generators. Device for Feeding Boiler Compound. Diesel Operation Justifies Expert Supervision	1010
Questions and Answers: Longitudinal and Girth Seam Strengths. Coil Spring Calculations	1013
Editorial Comment: Specifications—Good and Bad. Water, Water Everywhere! European and American Design Practice. How Is the Coal Fired?	1014
Elastic Disc Expansion Joint	1016
High-Pressure Bypass Oil Filter	1016
High-Pressure Feedwater Heaters	1017
Small Pressure Regulator	1018
New Boilers and Generating Units for Hudson Ave	1018
Record-Breaking Turbine Generators for Brooklyn Edison Co.	1020
News Notes	1019
Books and Catalogs	1020
Power Plant Construction News	1022

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Sixty Miles Per Minute!

SIXTY MILES per minute! Gosh, what a time we've had with that heading. The compositor insisted that our copy was wrong and three times he set it up sixty miles per *hour* (no, we don't mean he set it up at that rate) and each time we had to mark it back to sixty miles *per minute*. He finally conceded, not without certain uncivil remarks about fool editors having their way, but we pretended not to hear him—we merely assumed an attitude of nonchalance and smoked a Murad. For we knew we were right; we meant to write sixty miles per minute.

Of course, we realize there was some justification for the compositor's attitude, although we can not excuse his insulting remarks. He, probably, is conversant only with such slow moving affairs as that in which Captain Hawks spanned the continent in less than 15 hours recently, or with Major Seagrave's record of 231 miles per hour in an automobile. Such snail-like paces are as nothing compared to our 60 miles per minute. At 60 miles per minute, Captain Hawks could travel from New York to San Francisco in an hour flat!

But, do we hear you say, no airplane can travel a mile a second? Well, we never said anything to that effect, did we? True, we put a photograph of some airplanes at the top of this column but that is merely an interesting picture we took of some army planes flying over Chicago, during recent maneuvers.

The sixty miles per minute? Oh, well, that's another story and has to do with the velocity of molecules in a magnet. You will find more about that on page 988, where we show some pictures of these molecules. These airplanes, however, looked so much like the diagrams of our molecules that we could not resist the temptation to direct your attention to the article in this manner. Just compare the above photograph with the diagram on page 988 and see whether we're not right.

New Plant Built out of Profits of Old at Independence, Mo.

New municipal plant built at a cost of nearly $300,000 without the sale of a single bond serves city with power and light at low rates.

AS PART OF A TEN-YEAR expansion program involving a complete modernizing of the existing power and light facilities, the municipality of Independence, Missouri, has recently completed the construction of a new power and light plant at an expenditure of nearly $300,000 without the sale of a single dollar's worth of bonds. The money was derived entirely from the profits of the lighting system, notwithstanding the fact that the rate schedule compares favorably with the rates in effect in adjoining territory served by privately owned companies. The rates, in fact, are among the lowest in the state for a city of this size.

The construction of this new plant was necessary because of the steady increase in the lighting load since 1921. In 1921 the kw-hr. output was 2,070,000 while in 1929 it was 7,600,000, a 3½ fold increase. Under the gradually increasing load conditions, the old plant was being strained to the limit of its capacity and as it was of rather antiquated vintage, a new plant was decided upon. All of the improvements since 1925 have been financed out of plant earnings.

The expansion over this five-year (since 1925) program called for the rebuilding of the plants' housing at a cost of about $40,000; the installation of a 1500-kw. turbo-generator and condenser at a cost of $65,000; the resetting and re-equipping of the boilers and the purchase of one new boiler at an expense of $55,000; a new smokestack at a cost of $8000; enlargement and modernization of the spray pond at a cost of $4000; the installation of a 2500-kw. turbo-generator and condenser, $85,000; installation of switchboard $12,500; underground conduit lines and steel tower for distribution lines, $7500; painting the plant and other repairs $2000 and miscellaneous construction incident to all of the expansion work, about $15,000.

The completion of this program gives the plant a rating at present, of about 5000 kw. in three generating units, one a 2500-kw. turbo-generator, another a 1500-kw. turbo-generator unit and the third a 1000-kw. engine driven unit which remains from the old plant but will be replaced probably by a new turbine unit.

In appearance and engineering features, the new plant, with particular reference to the turbine room, is all that could be desired. The boiler room still has in it some old equipment which, of course, detracts somewhat from its appearance but this will be replaced by new in the future.

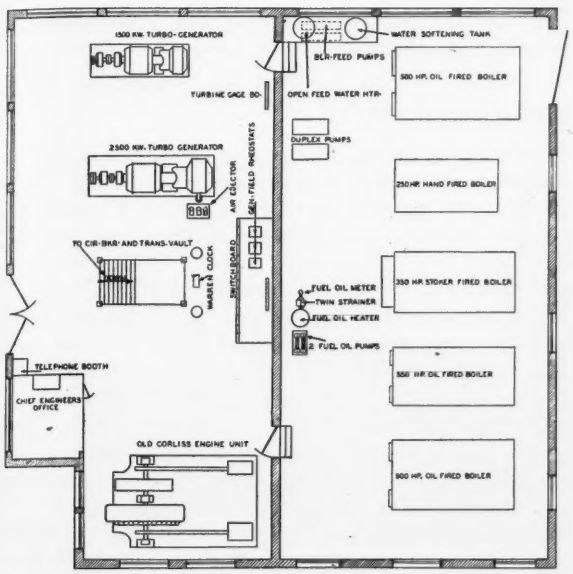


FIG. 1. GENERAL LAYOUT OF EQUIPMENT AND ARRANGEMENT OF PLANT

To show the progress that has been made, a view of the plant as it was in 1925 is shown in Fig. 5A while the new plant may be seen in Fig. 2 and also in Fig. 5E. The improvement needs no comment, about the only thing which can be recognized in the second picture is the one chimney.

The old plant consisted of three engine-driven generator units and one turbo-generator together with four boilers. One of the engine-driven units consisted of a Hamilton Corliss cross-compound engine driving a 1250-kv-a., 2300-v., 60-cycle generator; the other two were of 250-kw. and 400-kw. capacity respectively. The turbine unit was an 1850-kv-a. Ridgway machine. Both the Hamilton Corliss unit and the Ridgway turbine unit are installed in the new plant although the former is kept only for emergency operation.

Revamping operations were started about 5 yr. ago. Up to that time, the power plant had been more or less neglected and the operating costs were high. First, a new building was constructed, the two small Corliss engine units removed and in their place, a new 2500-kw. Westinghouse turbine installed. The engine room, now the turbine room, was completely redesigned. The old Hamilton Corliss engine still remains at one end of the room in the section of the old building which still remains at one end.

To supply the additional steam required by the new turbine, a new 500-hp. Henry Vogt boiler was installed. At the same time, an oil burning system was put in, not only on the new boiler but also on three of the old boilers. This has proved very satisfactory.

A new switchboard is a feature of the turbine room. This is a thoroughly modern board in every respect, with no live parts exposed. All oil circuit breakers, transformers and related high-tension equipment are located in a room in the basement below the switchboard. This room was excavated out of solid rock and its construction required considerable work. The house transformers are located here but the house lighting and power circuits are controlled from an enclosed steel panel behind the main switchboard.

Finally a Telechron clock system with a Warren master clock was provided, making Telechron time service available to all customers in Independence.

The general arrangement of equipment in the plant is shown in Fig. 1. As will be noted, a portion of the former building still remains, this housing the Corliss engine. The five boilers are arranged in a single row with their fronts facing the dividing wall between the boiler and turbine rooms.

Boiler Room Equipment

The new boiler unit is at one end of the room as shown. It is a 500-hp. Henry Vogt, water-tube boiler with 5006 sq. ft. of water heating surface and 296 sq.

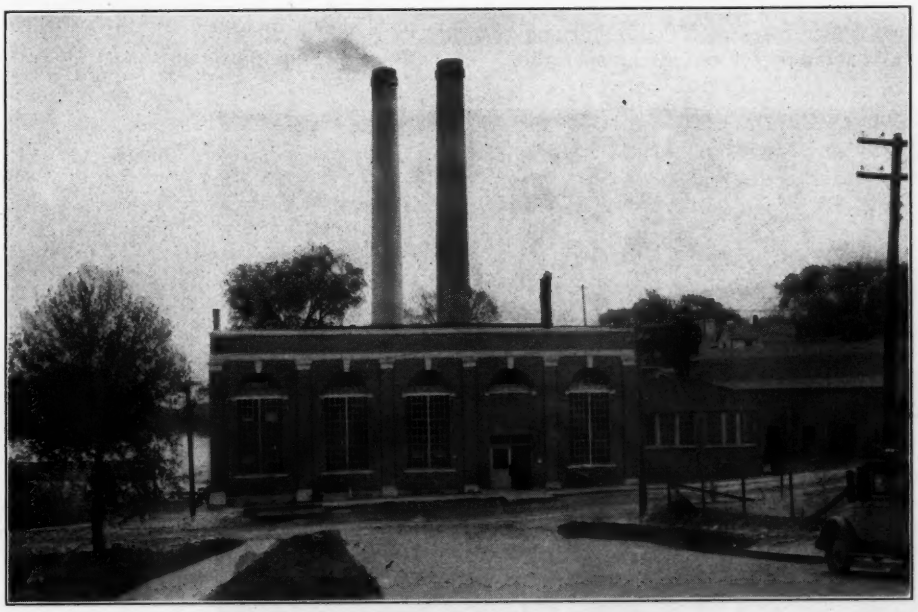


FIG. 2. AN EXTERIOR SHOWING THE NEW PLANT WITH A PORTION OF THE OLD AT THE RIGHT. THE COOLING POND IS AT THE RIGHT

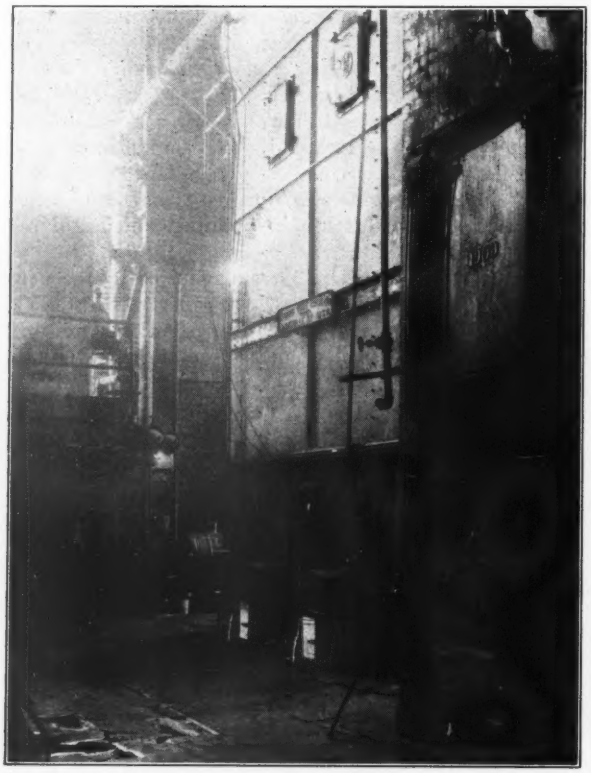


FIG. 3. A VIEW IN THE OLD BOILER ROOM SHOWING THE NEW 500-HP. BOILER

ft. of surface in the Elesco superheater with which it is equipped. It is built for 360 lb. steam pressure although, at present, it is being operated at only about 150 lb. It is arranged to burn oil and operated under natural draft, the latter being supplied by a new concrete stack.

The other four boilers are units which served in the old plant. They consist of the following:

1—Hand-fired boiler rated at 250 hp., burning coal but used only as a stand-by for emergency operation.

1—350-hp. coal-fired unit fitted with a Westinghouse underfeed stoker.

2—Units of 350 and 500 hp. respectively, both equipped for oil burning.

Fuel oil is stored in three tanks outdoors and is pumped to the burners at a pressure of 110 lb. by either of two duplex pumps. Leaving the pumps, it passes successively through a home-made heater using exhaust steam, an Elliott twin strainer and a Worthington meter to the burners. Mechanical atomization is employed.

Boiler feed is city water treated by a Paige and Jones Zeolite treating system and heated by a Cochrane open heater. Two boiler feed pumps are provided, both simplex steam pumps. The exhaust is used for heating feedwater and fuel oil.

For the coal-fired boilers, an overhead bin is provided. Coal is delivered by railroad cars to a storage bin. A drag chain under the storage pile and a bucket elevator deliver the coal to the upper part of the boiler room. This in turn delivers to a screw conveyor which distributes it to the overhead steel bunkers. A traveling weigh larry transfers it from the overhead bunkers to the stoker hopper in the case of the stoker-fired boiler or to the floor in front of the hand-fired unit.

Steam flow is measured by Bailey and Republic steam flow meters and CO_2 by a Republic CO_2 recorder.

Plans are now under way for two new 500-hp. bent tube boilers. One unit will be equipped with a chain grate stoker forced and induced draft, superheater, air preheater and water-cooled walls. The other unit will be fired with oil and equipped with preheater and induced draft. A new addition to the building will be required as well as ash handling equipment, steam piping, etc. The estimated cost of the new improvement to be completed in 1930 is $113,464.00. A reduction of 7½ per cent in fuel consumption will be obtained by the use of the air preheaters. A reduction of 10 per cent in fuel costs is expected from the use of coal instead of oil. A cross section of the new boiler equipment is shown in Fig. 6.

Principal equipment in the turbine room consists of

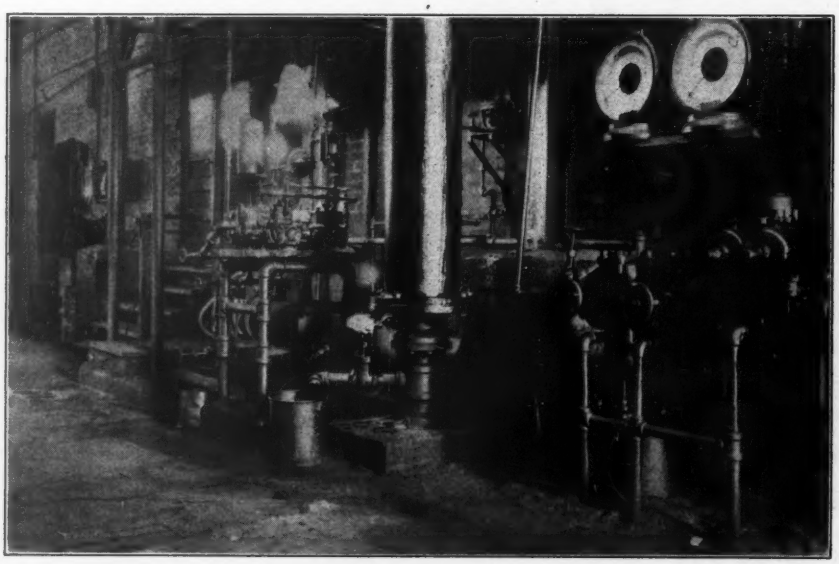
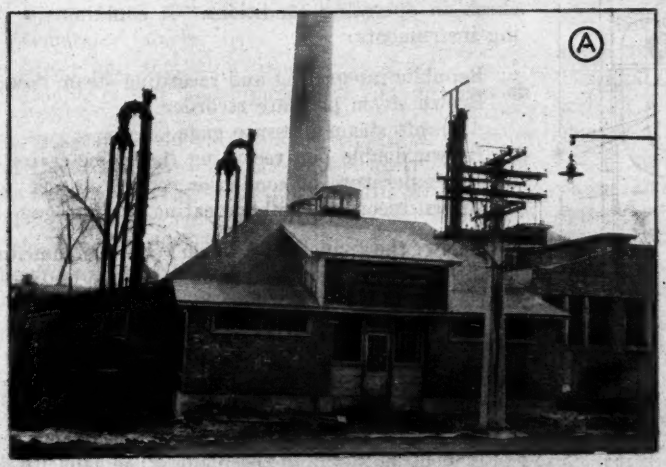
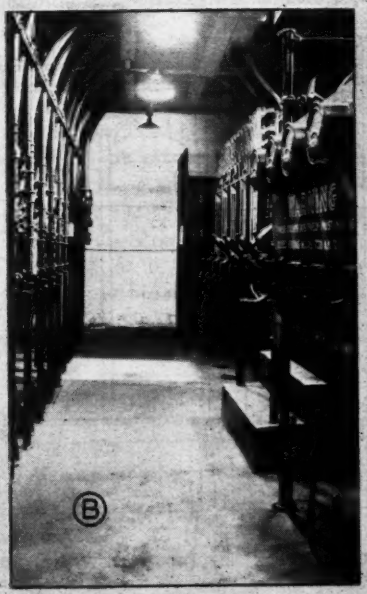
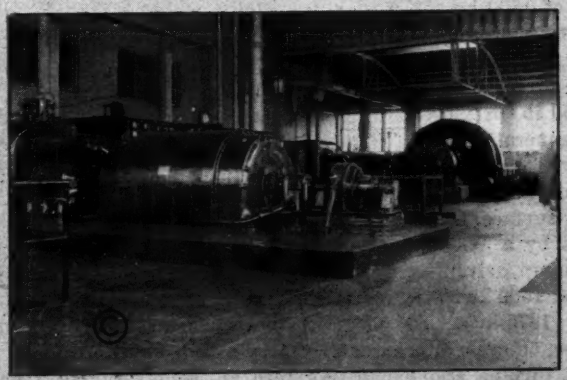
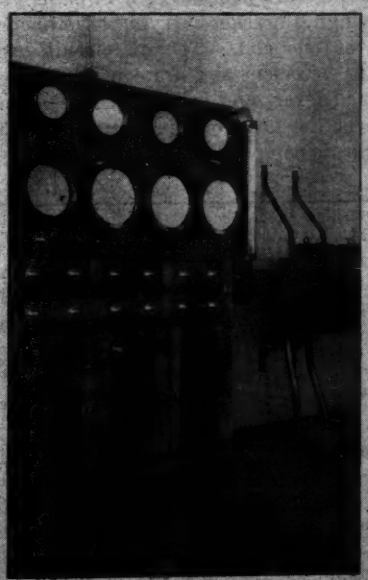


FIG. 4. THE STEAM DRIVEN FUEL OIL PUMPS AND THE HOME-MADE OIL HEATER. AT THE RIGHT ARE SHOWN THE TWIN OIL STRAINERS AND THE FUEL OIL METER









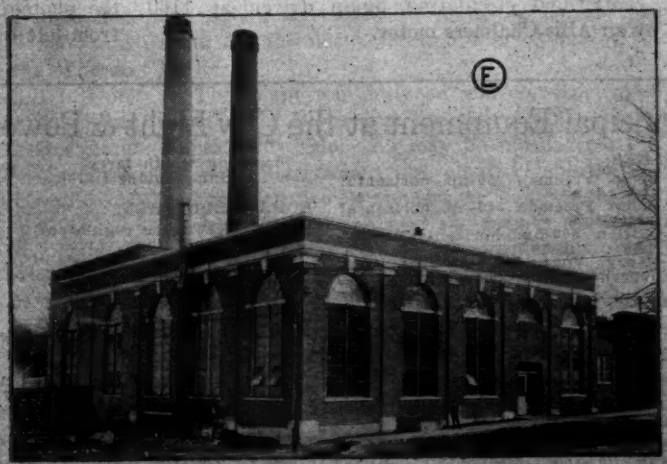


FIG. 5. DETAILS OF INDEPENDENCE MUNICIPAL PLANT

A. A view of the old plant before the new construction program.

B. All high voltage equipment, transformers, circuit breakers, etc., are in a vault in the basement.

C. A general view in the turbine room looking toward the old engines.

D. The turbine gage board. Note cabinets and drawers below for keeping charts and record forms.

E. A view of the new plant as it is at present.

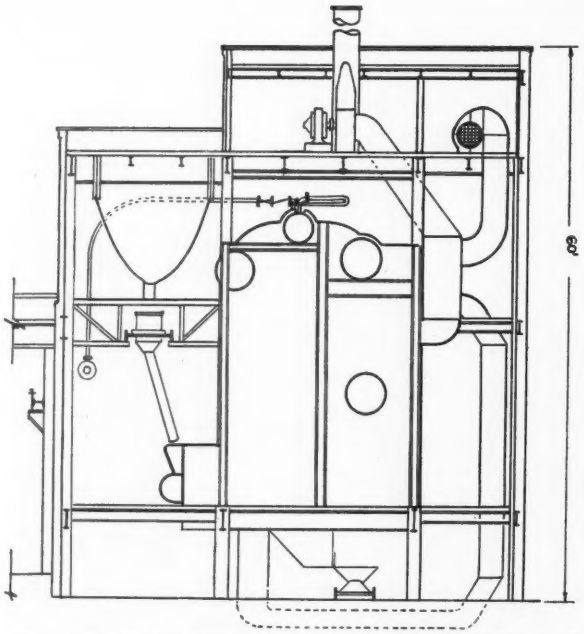


FIG. 6. SECTION THROUGH NEW BOILER PLANT, CONSTRUCTION OF WHICH IS NOW IN PROGRESS

two turbo-alternators, one of 2500-kw. capacity and the other of 1500 kw. The 2500-kw. unit is a new machine consisting of a 3125-kv-a., 2300-v., 80 per cent power factor, 3-phase, 60-cycle, 3600-r.p.m. Westinghouse generator direct connected to a Westinghouse turbine, built for 350 lb. pressure but operating at present at 150 lb. The generator is fitted with a 22-kw., 125-v. shaft exciter.

This machine is served by a 5700-sq. ft. Westinghouse surface condenser, having a circulating pump driven by a Westinghouse 75-hp. motor and a condensate pump driven by a 5-hp. motor of the same make.

The 1500-kw. machine is a Ridgway unit consisting of an 1875-kv-a., 80 per cent power factor, 2300-v., 3-phase, 60-cycle alternator driven by a Ridgway Rateau Smoot turbine and exhausting into an Elliott surface condenser. The latter is served by a 3500-g.p.m. DeLaval, centrifugal circulating pump driven at 1160 r.p.m. by an Allis-Chalmers motor.

An important feature of the turbine room is the gage board shown in Fig. 5D. This contains the necessary recording and indicating gages used in keeping a check on operating conditions. It contains the following instruments:

Republic integrating and recording steam flow meter
Brown steam pressure recorder
Ashcroft steam pressure gage
Brown double pen recording thermometer for measuring temperature of condenser cooling water.
Brown recording and indicating vacuum gage

Below the panel on which the instruments are mounted are drawers and compartments for filing the charts.

The Westinghouse condenser on the 2500-kw. unit is served by a Westinghouse Leblanc air ejector with inter and after condenser, installed on the turbine room floor next to the turbine.

Cooling water for the condenser is drawn from a spray pond adjacent to the plant. The capacity of this pond has been increased recently by the installation of an additional row of spray nozzles.

At the present time, both turbines are being operated at 150 lb. steam pressure, although the large unit is built for 350 lb. It is planned, however, during this year to add two additional high-pressure boilers and either a high-pressure element to the Ridgway turbine or an entirely new turbine and then both units will operate at 350 lb. This, of course, will materially increase the economy of the station, in fact, the full load steam consumption of the turbine will drop from 16 to 11.42 per kw-hr. when this change is made. Practically all auxiliaries will be made motor driven and the proper heat balance will be maintained by bleeding steam from the main unit at two points.

Electrical Features

The main switchboard consists of a 14-panel vertical board with a swinging bracket carrying a voltmeter and synchronoscope at one end. The oil circuit breakers are located in the basement and are controlled, mechanically, by means of levers and bell cranks. As shown in the photograph at the head of this article, this board, from left to right, is composed of

Principal Equipment at the City Light & Power Plant at Independence, Mo.

BOILERS:
- 1 Bonus Freeman 250-hp. horizontal water tube
- 2 Bonus Freeman 350-hp. horizontal water tube
- 1 O'Brien 500-hp. horizontal water tube
- 1 Henry Vogt 500-hp. bent tube Superheater—Superheater Co.

FUEL EQUIPMENT:
- 250-hp. Boiler—hand-fired.
- 350-hp. Boiler—Westinghouse single retort stoker
- 350-hp. oil-fired
- 500-hp. Oil-fired
- 200-hp. Oil fired

COAL HANDLING EQUIPMENT:
- Storage—below siding
- Drag chain conveyor
- Bucket elevator
- Screw conveyor
- 50-t. unlined suspension type steel bunker
- Traveling weigh larry

Ash Handling—Industrial—car

BOILER EQUIPMENT:
- Copes feedwater regulators
- Edward nonreturn valves
- Blowoff valves
- Diamond Power Spec. Corp. soot blowers
- Reliance water columns

Breeching—3/16-in. steel plate
Stack-Weber reinforced concrete 110 ft. high by 7 ft. dia.
Forced draft fans—Sturtevant
- 1 Steam driven, 1 Electric driven

Water supply—City
- Treatment — Paige - Jones Zeolite Softener

Feed heater—1 Cochrane open type
Boiler Feed Pumps:
- 3 Union Simplex, 150 g.p.m., 109 g.p.m., 60 g.p.m.

Main Units:
- 2500-kw. Westinghouse, 2300-v. turbine generator
- Westinghouse, 5700-sq. ft. surface condenser
- Westinghouse air ejector
- Ridgway Dynamo & Engine Co. 2300-v., 1500-kw. turbine generator
- Elliott Co. 4000-sq. ft. surface condenser
- Elliott Co. air ejector
- 1000-kw. engine generator—Hooven, Owens, Rentschler Co., 2300-v.
- Westinghouse generator
- 20-in. barometric condenser

Exciters driven by main units
Circulating water cooled in spray pond —4500-g.p.m.
Switchboard, panel type, remote manual control

MISCELLANEOUS EQUIPMENT:
- Whiting 10-t. traveling crane
- Gardener Rix 6 by 6-in. air compressor
- Hill and Dayton Dowd Co. Sump pump
- Reed air filters for turbine generator

1—Voltage regulator panel
1—Future exciter panel
3—Exciter panels
1—Blank panel, for future generator
3—Generator panels
1—Meter and totalizing panel
4—Double circuit feeder panels for city distribution

The generator field rheostats are placed on the floor behind the switchboard and are motor operated except for the rheostat serving the 1000-kw. engine-driven unit. The latter is mechanically operated by a rod and chain from the front of the board.

The Warren master clock by which the frequency of the system is checked is shown between the two ornamental lamp posts directly in front of the switchboard. This is a highly accurate pendulum clock the time of which is checked daily by radio from the wire chief's home. The clock has one dial with a second hand which also carries on the same shaft a second hand controlled by a Telechron clock. This hand normally moves in exact coincidence with the second hand of the Warren clock. If the frequency of the system should fall off over a short period of time, however, this Telechron second hand would lag behind that of the master clock or if it should gain, the hand would be displaced the other way. In either case, the displacement would indicate to the operator that the frequency needed adjusting which he would do until the two hands were coincident once more.

Conclusion

As a consequence of the addition of these modern improvements, the expense of operation has greatly decreased. Whereas in 1925 when the sale of current amounted to $160,000 the expense of operation was 80.1 per cent of the sale of energy, last year the percentage of operation cost was only 63.3 against sales of energy amounting to $245,889.37.

In 1929, even though the new plant was not entirely completed, the profits of operation amounted to $71,768.69 after more than $20,000 had been set apart in the depreciation and obsolescence fund.

The above profits do not take into consideration the fact that the city is furnished with all street lighting and lights to public buildings without cost to taxpayers. The total bonded indebtedness of the plant is $45,000.00 and in the department there is nearly double this amount of ready cash on hand.

In spite of this increased revenue, the rates for power and light have been materially reduced and as stated before, the rates are as low as any in the state. For residence service, the first 30 kw-hr. are delivered at 6½ cents, the second 30 at 5½ cents and all over 60 kw-hr. at 5 cents. A combination rate, based on 5 kw-hr. per room is also furnished in which the first 25 kw-hr. are delivered at 6½ cents, the second 25 at 4½ cents and all over 50 at 2½ cents. The power rates are 5 cents per kw-hr. for the first 250 kw-hr., 4 cents for the second 250 kw-hr., 3 cents for the next 2000, 2½ cents for the next 2500 and 2 cents for all over 5000 kw-hr.

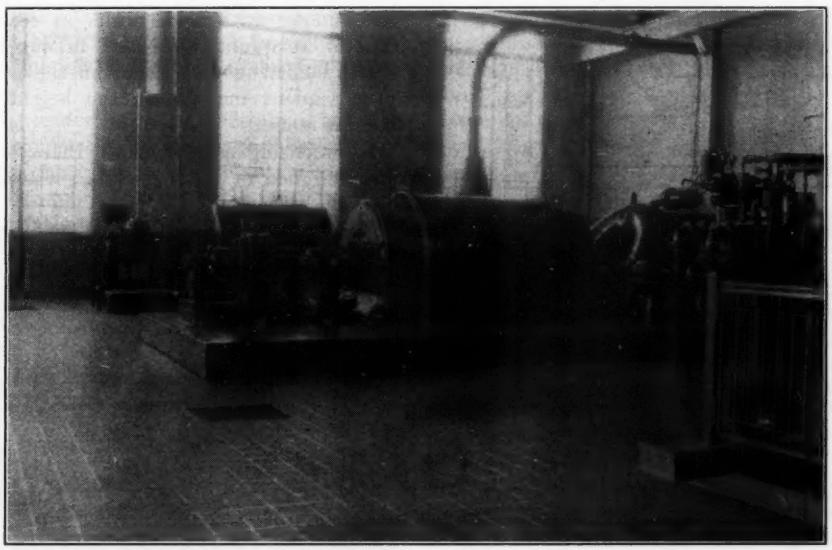


FIG. 7. THE NEW WESTINGHOUSE TURBO-GENERATOR UNIT

This plant was designed and constructed under the direction of Black and Veatch, consulting engineers of Kansas City, Mo. As may be noted from the accompanying illustration, the plant is substantially built and is attractive in appearance. A general atmosphere of neatness has displaced the former unkempt appearance a fact which contributes considerably to the interest which the operators display in their work. Cleanliness and plenty of light make for safety and dependability. The turbine room has a red tile floor, cream colored brick walls with a light brown wainscoting. All exposed steelwork is painted aluminum and the mechanical equipment is painted green. The room is served by a 10-t. Whiting traveling crane.

In presenting this description, we are indebted to Mr. Fischer, chief engineer of the plant, and to Black and Veatch, the consulting engineers, for assistance rendered in collecting the data on which it is based.

Novel Pump Arrangement Shows Savings

UNUSUAL HOTWELL AND FEED PUMP ARRANGEMENT AT DELRAY NO. 3 WHICH GIVES HIGH EFFICIENCY AND SAVES HEADROOM. BY ARTHUR MCCUTCHAN*

IN DELRAY POWER HOUSE No. 3 of the Detroit Edison Co. the feedwater system is a natural development of one used in the Trenton Channel Power House of the same company. In this arrangement, the condensate and boiler feed pumps are a unit with the main unit condensers rather than elements of a general plant feedwater supply. The necessary variation in quantity of water in the feed circuit due to changes in station load is controlled by high and low level floats in the main condenser hotwells. These floats operate valves which permit the discharge of excess water from the hotwell pumps to storage through a back pressure valve or admit water from storage into the main condenser hotwell.

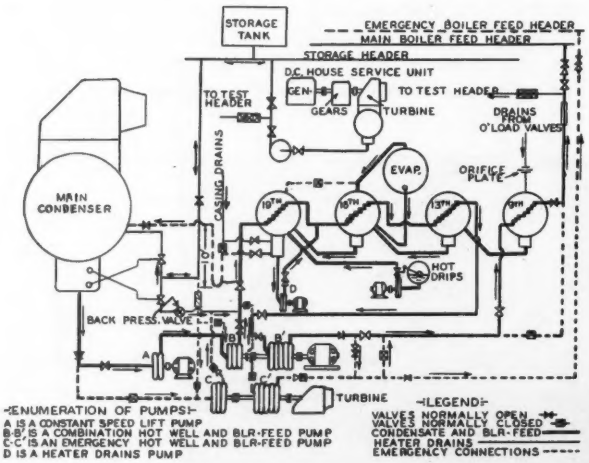


FIG. 1. CONDENSATE AND BOILER FEED PIPING DIAGRAM OF DELRAY NO. 3

Condensate from the direct-current auxiliary units is returned to the feedwater circuit through the storage header and the low level float controlled valves, consequently, as steam to auxiliary units creates a constant deficiency, the system normally operates under control of the low level floats. Storage water is admitted near the center of the condenser and is cascaded over a series of angle irons down to the water level in the hotwell. The combination of high vacuum and mechanical breaking up of the water results in effective deaeration.

Arrangement of pumping and feed heating equipment is shown diagrammatically in Fig. 1. It will be noted that water is taken from the hotwell by a so-called lift pump which raises the pressure slightly above atmospheric and discharges directly to the hotwell pump which is connected to the shaft of the boiler feed pump. The lift pump is driven by a direct-current constant speed motor at approximately 600 r.p.m. The combination hotwell and boiler feed pump unit is driven by an adjustable speed direct-current motor at 1000 to 1200 r.p.m.

It should be noted that the speed of the combination unit is determined by the requirements of the boiler feed pump and its driving motor. In order to maintain a reasonable diameter of pump impeller and reduce the number of stages required, the boiler feed pump is designed for as high speed as is compatible with satisfactory operation of the large direct-current driving motor, i.e. 1200 r.p.m. This speed is too high for a hotwell pump operating under the suction conditions usually encountered with main units in central stations. In general, it would necessitate raising the condensers to secure sufficient static head on the pump suction, with a consequent increase in the height and cost of the turbine house.

Condensing equipment at Delray Power House No. 3 is designed to operate at high vacuum and with very little undercooling of the condensate. Both of these conditions tend to increase the height of water column necessary to insure proper performance of the hotwell pump. The temperature of the condensate is such that either a slight increase in temperature or a reduction in pressure will produce cavitation due to flashing in the suction pipe and pump casing. Such cavitation is manifest as a distinct rattle produced by alternate slugs of water and vapor going through the pump. Operating a pump under such conditions lowers its efficiency and at the same time increases wear and maintenance.

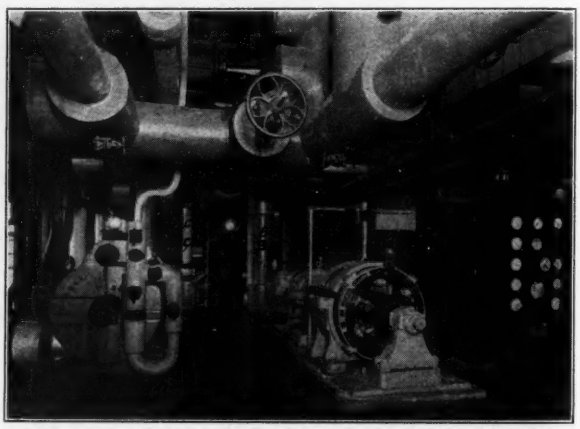


FIG. 2. STEAM AND ELECTRIC BOILER FEED PUMPS AS INSTALLED

CAVITATION CAN BE REDUCED BY TWO METHODS

Two methods are available to prevent cavitation in a hotwell pump. The first and most common is to place the pump far enough below the water level in the condenser hotwell to effectively drown it. This is accomplished if the column of water on the suction of the

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pump is sufficient to exert an elevation head at the entrance of the impeller in excess of any possible reduction of head in operation. The amount that the pressure is reduced at the eye of the impeller of a centrifugal pump is dependent upon friction loss in the suction pipe and upon the design of the impeller and the speed of the pump. The foregoing is predicated on the existence of an ample size vent pipe between the condenser and the suction chamber of the pump casing. The second method of preventing cavitation is to reduce the loss of head entering the hotwell pump by introducing an additional pump in series between condenser and hotwell pump, operating at low speed and having a very small pick-up loss. With such a pump, the necessary height of water in the condenser hotwell is much reduced.

Thus, at Delray No. 3 the insertion of a special slow speed, low head pump between the condenser hotwell and the hotwell pump proper eliminated this difficulty at a fraction of the cost of the additional building cubage that might have been required to secure adequate head at the suction of the type of hotwell pump employed.

Incidentally, the center line of the lift pump is lower than that of the combination hotwell and boiler feed pump, thus affording an increase of available static head of 16 per cent on the pump taking water from the condenser for the normal operating level in the condenser hotwell and an increase of more than 26 per cent for the minimum operating level. The lift pump, being a separate entity, is located close to the hotwell reducing friction losses in suction line to a minimum. The relative locations of condenser, lift pump and combination hotwell and boiler feed pumps are shown in Fig. 2.

While improvement in efficiency was not the principal reason for the use of a lift pump, it is interesting to note that the gain in overall efficiency of the pumping equipment credited to the lift pump is nearly double that which would have been obtained by adding another stage to the hotwell pump. This is due to low velocity of water entering the impeller, large size of pump, low speed and small head discharged against, all of which are favorable to efficient design of a pump removing condensate from a hotwell.

Overall Pump Efficiency of 73 Per Cent

The motor-driven pumping equipment removes water from the condenser, passes it through extraction heaters and delivers it to the boilers with an overall pump efficiency of approximately 73 per cent at rated load on the pumps. The work is performed in three pumps having a total of 10 stages.

The turbine-driven emergency pumping equipment does not use a lift pump but takes water directly from the condenser hotwell and delivers it through extraction heaters to the boilers. The work is divided into eight stages with an overall efficiency of 67 per cent at rated load on the pumps. The overall efficiency of the turbine-driven equipment could have been increased to 69 per cent by the addition of another stage to the hotwell pump.

Above efficiencies are guarantees and presuppose smooth operation without cavitation. In operation, this condition obtains with the motor-driven equipment which performs smoothly and quietly. The turbine-driven hotwell pump, because of its high speed, 1700 r.p.m., an insufficient static head on suction is somewhat noisy, due to cavitation, as was of course anticipated. The emergency nature of this equipment did not warrant any elaboration to improve efficiency or quietness of operation.

Use of a lift pump results in approximately a five per cent reduction in power consumption for returning condensate from condensers to boilers. Assuming a 50 per cent use factor and computing the annual saving of fuel cost, the capitalized value of this saving is enough to pay the carrying charges on the additional investment required, which is a satisfactory return in view of the essential nature of the equipment. Where adequate head is available on the hotwell pump suction to prevent cavitation, the addition of a lift pump would be classed as optional equipment and could not be justified on an energy saving basis even for an improvement in efficiency as large as resulted in this instance.

Combined Industrial and Public Utility Plants

Advantages of Lower First Cost and Higher Economy Apparent But Practical Difficulties Make Progress Slow. By W. F. Ryan*

WHILE THE ADVANTAGES of private power generation in high-pressure prime movers are obvious and are being convincingly demonstrated, few industries are capable of developing this idea to its economic limit. The big power consuming industries, for example, automobile manufacture, are not great consumers of process steam; frequently a seasonal heating load is the only steam demand. On the other hand, the big consumers of exhaust steam, oil refineries, salt works and alkali plants, are relatively small consumers of electric power. Moreover there is frequently a regrettable lack of synchronism between the demands for these two forms of energy. For example, in many industries the greatest single item of power consumption is for pumping cooling water; this load is greatest in the summer months. An important item of steam consumption is usually the heating of buildings; this demand occurs only in the winter. There are other variations between summer and winter, between day and night, and between Sundays and week-days that make private generation of power unduly expensive in most industries, and impracticable in many.

Full economic value of the high back pressure prime mover can be developed only by coöperation between industries and public utilities for the combined production of process steam and electric power. Coöperation of this type has been discussed academically for some time, but it is only now beginning to find practical appli-

*Abstract of a paper presented before the World Power Conference in Berlin.

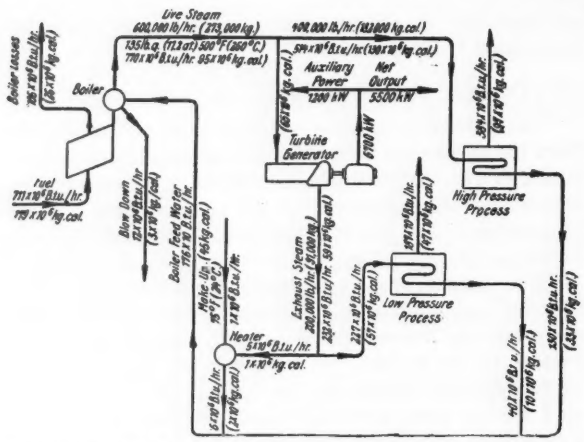

Live Steam
600,000 lb./hr. (273,000 kg.)
135 lb. g. (17.3 at.) 500°F (260°C)
770 x 10⁶ B.t.u./hr. 95 x 10⁶ kg. cal.)
408,000 lb./hr (183,000 kg. cal.)
59 x 10⁶ B.t.u./hr (30 x 10⁶ kg. cal.)
Auxiliary Power 1200 kW
Net Output 5500 kW
Turbine Generator
6700 kW
Boiler
Boiler Losses
28 x 10⁶ B.t.u./hr.
(6.5 x 10⁶ kg. cal.)
Fuel
771 x 10⁶ B.t.u./hr.
179 x 10⁶ kg. cal.
Blow Down
12.4 x 10⁶ B.t.u./hr.
(3.1 x 10⁶ kg. cal.)
Boiler Feed Water
195°F (91°C)
Make-Up 15°C (59°F)
1 x 10⁶ B.t.u./hr.
(1 x 10⁶ kg. cal.)
Heater
5 x 10⁶ B.t.u./hr.
1 x 10⁶ kg. cal.
Exhaust Steam
280,000 lb./hr (127,000 kg.)
283 x 10⁶ B.t.u./hr. (64 x 10⁶ kg. cal.)
227 x 10⁶ B.t.u./hr.
(51 x 10⁶ kg. cal.)
High Pressure Process
Low Pressure Process
(41 x 10⁶ kg. cal.)
(101 x 10⁶ kg. cal.)

FIG. 1. HEAT BALANCE DIAGRAM OF AN ISOLATED INDUSTRIAL PLANT

cation. This step is the outstanding development in the field of industrial power and heat supply today.

As an example of the possibilities of coöperative steam and power production, consider a relatively large industrial plant, having an average steam demand of 600,000 lb. per hour. Two-thirds of this steam is used at boiler pressure, and the remainder at a lower pressure, after passing through noncondensing turbine generators. The power demand of the mill, which is only 5500 kw., is easily and economically supplied in this way. Figure 1 shows the essential features of the plant heat balance with heat flows given to the nearest million of heat units, above 32 deg. F. Steam is generated in an efficient boiler plant, the entire electric power requirements are generated in noncondensing prime movers with a thermal efficiency of about 95 per cent. The whole installation approaches the limit of economical heat and power supply for this particular industry.

The territory in which this plant is situated is served by a central station, which is also highly efficient. The essential features of its heat balance are outlined in Fig. 2. Steam is supplied to the turbine throttles at 625 lb. ga. and 750 deg. F. The turbines exhaust at a vacuum of 29 in. Hg. There are four stages of regenerative feedwater heating and the boilers are as efficient as those of the lower pressure industrial plant. The overall fuel consumption is at the rate of less than

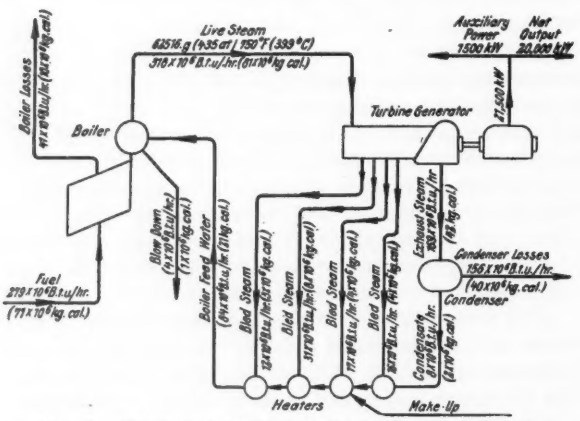

Live Steam
625 lb. g (435 at.) 750°F (399°C)
518 x 10⁶ B.t.u./hr. (131 x 10⁶ kg. cal.)
Auxiliary Power 7500 kW
Net Output 20,000 kW
27,500 kW
Turbine Generator
Boiler
Boiler Losses
41 x 10⁶ B.t.u./hr. (10.4 x 10⁶ kg. cal.)
Fuel
279 x 10⁶ B.t.u./hr.
(71 x 10⁶ kg. cal.)
Blow Down
(4 x 10⁶ B.t.u./hr. (1 x 10⁶ kg. cal.)
Boiler Feed Water
(64 x 10⁶ B.t.u./hr. (16 kg. cal.)
Bled Steam
123 x 10⁶ B.t.u./hr. (31 x 10⁶ kg. cal.)
Bled Steam
51 x 10⁶ B.t.u./hr. (13 x 10⁶ kg. cal.)
Bled Steam
77 x 10⁶ B.t.u./hr. (19 x 10⁶ kg. cal.)
Bled Steam
32 x 10⁶ B.t.u./hr. (8 x 10⁶ kg. cal.)
Exhaust Steam
283 x 10⁶ B.t.u./hr. (72 kg. cal.)
Condenser Losses
156 x 10⁶ B.t.u./hr.
(40 x 10⁶ kg. cal.)
Condenser
Condenser's
87 x 10⁶ B.t.u./hr.
(22 x 10⁶ kg. cal.)
Heaters
Make-Up

FIG. 2. HEAT BALANCE DIAGRAM OF A CENTRAL STATION

13,000 B.t.u. per kw-hr. generated, and less than 1 lb. of good steam coal per kw-hr. of net output. This also approaches the economic limit for a station of this type. Figure 3 shows the economies that can be effected by combining the functions of these two power stations in a single plant, producing the same quantities of steam for process, and the same net output of electric energy. Instead of the total heat consumption, 990 million B.t.u. per hr. required for the two individual plants, we have a heat consumption in the combined plant of only 800 million B.t.u. per hr., a saving of 19 per cent. Had we assumed a more efficient central station, with higher initial pressure, reheat, and additional stages of feedwater heating, the fuel saving would have been proportionately greater.

The above fuel saving is based on the ideal condition illustrated in Fig. 1, where the demand for exhaust steam is precisely equal to the supply. This never occurs in practice. Either there is an excess of exhaust steam which is blown to the atmosphere, or concealed by wasteful application in process, or there is a deficiency of exhaust steam, and live steam is supplied through a reducing valve. In one case there is a total loss of valuable heat, in the other a degradation of energy and loss of potential power. Under any practical conditions, therefore, the saving should be greater than that indicated by these heat balance diagrams.

Many industrial boiler plants are operated in whole or in part on waste fuel. If 50 per cent of the heat supplied to the boilers in Fig. 1 is waste fuel and this waste is utilized in the combined plant of Fig. 3, then the saving in purchased fuel is 30 per cent.

Analysis of the more important wastes in three heat balances shows that the fuel saving in the combined plant is effected by a 22 per cent decrease in auxiliary power consumption (largely due to elimination of condenser auxiliaries) 13 per cent reduction in blowdown losses, 28 per cent reduction in other boiler losses and 100 per cent elimination of condenser losses. Reduction of radiation, leakage, friction and generator losses, not taken into account on these diagrams, should offset, in large part, the transmission losses incident to the combination.

Under favorable circumstances, the cost of a combined steam and power plant of this kind will cost less than two separate plants for the two functions. If the combination involves transmission of power or steam over great distances, or if the loss of steam in process

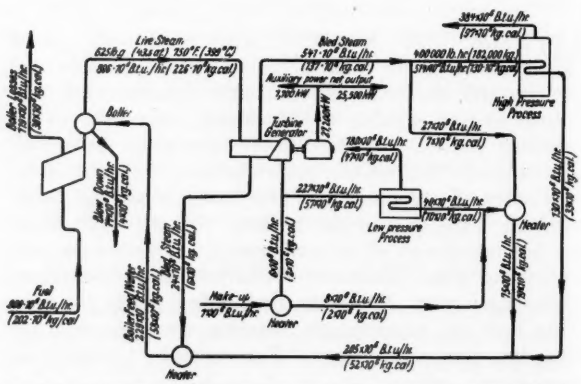


FIG. 3. COMBINING THE CENTRAL STATION AND INDUSTRIAL PLANTS SHOWS A SUBSTANTIAL SAVING

necessitates the installation of expensive evaporators, the case may be reversed; but there are obvious savings in the elimination of condensers and circulating water supply, and the reduction in the number of boilers and other items of equipment. These savings are not offset by the greater amount of high-pressure piping and equipment. For the particular case under discussion, the capital cost is estimated as follows:

Cost of complete industrial power plant, in accordance with Fig. 1, including land, auxiliary structures, etc.	$2,168,000
Increment cost, for capacity assumed in Fig. 2, for large central station, including land, auxiliary structures, etc.	2,220,000
Total cost, separate plants	$4,388,000
Complete cost, combined plant, in accordance with Fig. 3, including land, auxiliary structures, etc.	3,928,000
Saving effected by combination	$ 460,000

If the combination plant is so situated that it can supply steam and power to several contiguous industries, then the cost of such a plant might be taken on an increment basis, as well as the central station. The same applies if an existing central station is so situated that it can supply one or more industrial plants without duplicating existing coal handling facilities and the like. Both of these cases result not only in a greater reduction of initial cost, but also in material savings in operating labor and maintenance.

Now, to discover the potential savings from the coöperative effort of industries and public utilities and to illustrate these savings by diagrams, is a very simple engineering problem. To put the idea into practice, and to convert these potential savings into cash, is a business problem which is not simple at all. There is a deep seated and well founded reluctance on both sides to invade what, up till now, they have each considered the domain of the other; however, our electric power companies have neglected few opportunities to extend their service, or to reduce their costs. Our manufacturers have been equally diligent in reducing production costs. These heat units and the dollars they represent will not be allowed to roll into the atmosphere and into the ocean forever.

The first requirement for the success of such a coöperative enterprise is that the advantages must be equitably divided between the two parties. If the plant is owned and operated by the manufacturer, the utility must be assured of the continuity of the power supply. If, on the other hand, the utility owns and operates the plant, the manufacturer must be assured of the reliability of his steam supply. If a plant is built under joint ownership, there must be a just division of costs between the two services. All three of these plans are in use in this country today. All require mutual confidence, good engineering, and intelligent management, and each party must have a sympathetic understanding of the problems of the other.

Graphic Comparison of Fuel Costs

Directions for Using Chart for Calculating Coal Requirements and Costs on the Boiler Horsepower-Hour Basis. By George W. Heald

THOSE CONCERNED with steam generation in the smaller or medium sized boiler plants will find the accompanying diagram convenient, for it enables quick and conclusive comparison of coal consumption or coal cost.

This diagram uses the pounds of coal per boiler horsepower per hour as abscissas between 2.8 lb. and 5.6 lb., which are the limits between minimum and maximum values ordinarily required in such calculations.

To illustrate the uses of this diagram, it will be assumed that 60 per cent combined boiler and furnace efficiency is being obtained with coal containing 11,000 B.t.u. per lb.:

(a) Starting at the left and in the central portion of the diagram, locate the line for 60 per cent efficiency; move horizontally to the right to the intersection with the diagonal line for 11,000 B.t.u. coal; this intersection will fall on the vertical line representing 5.08 lb. of coal per boiler horsepower-hour.

(b) Assuming that equipment is substituted to develop 80 per cent efficiency with the same grade of coal; the intersection of the 80 per cent horizontal line with the 11,000 B.t.u. diagonal falls on the vertical line having the value of 3.82 lb. per boiler horsepower-hour.

(c) If the cost of this coal is $4.00 per ton delivered to the boiler room, the relative coal cost for each condition, (a) and (b), will be found by following the respective vertical line down to the diagonal line marked $4.00 per ton and finding the unit coal cost horizontally to the right or left of these intersections; thus, the vertical line for 5.08 lb. intersects the $4.00 line at 1.015 cent, and the vertical line for 3.82 lb. the same line at 0.76 cent; the difference, 0.255 cent, multiplied by the average boiler horsepower-hours for a certain period of time, a day, week, month or year, will give the saving in coal cost during the period used due to the change in firing equipment.

Going back to the figures first found by the diagram, (a) 5.08 lb. and (b) 3.82 lb., if the coal consumption, say, for a year was known under the first condition, the consumption under the second condition will be directly proportional to these two figures. Thus, if 4000 t. of coal per year were used under the first condition, the quantity under the changed, or second, condition will be 3007 t. The difference, 993 t. at $4.00 per ton amounting to $3972, will represent the value of the coal saved due to the changes made. Thus, the saving to be expected from the installation of more efficient burning equipment or the use of lower priced coal can be quickly and accurately determined.

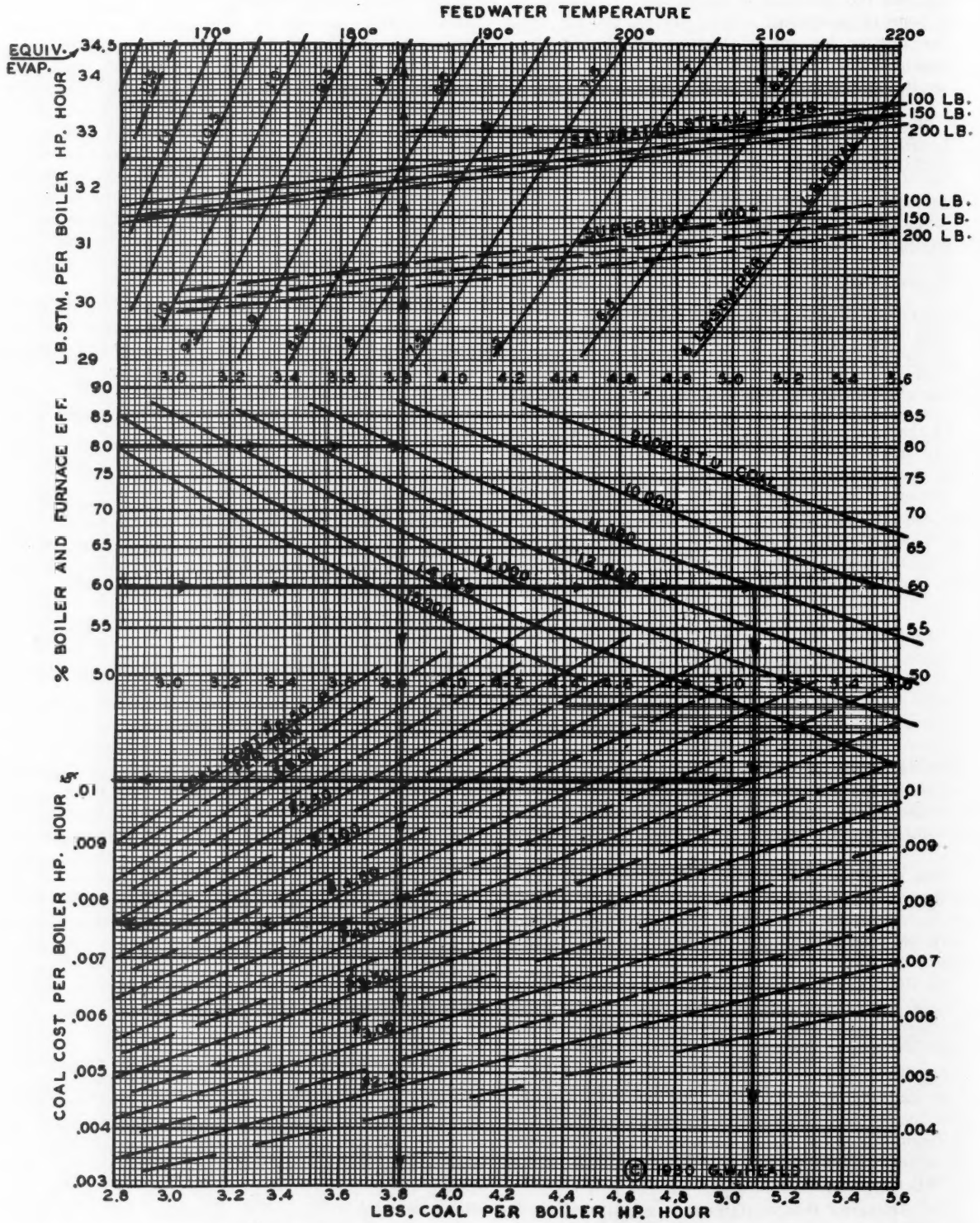


CHART FOR MAKING COMPARISONS OF BOILER PERFORMANCE

If, instead of starting with the combined boiler and furnace efficiency, the actual evaporation of steam in pounds per pound of coal is known, the start will be made in the upper portion of the diagram, looking first for the intersection of the steam pressure with the feedwater temperature. From this intersection, move horizontally until the diagonal representing the actual evaporation is reached. Then move vertically down to the intersection with the diagonal line reading "Coal B.t.u." and the corresponding efficiency will be found from the horizontal lines.

Following the same vertical line farther down, the unit coal cost is found in the manner previously explained.

It will be noticed that the upper line of the diagram is marked "Equivalent Evaporation" and the value 34.5 lb. given to it. So, after the horizontal intersection of the pressure-temperature line with the diagonal for the actual evaporation is found, the corresponding equivalent evaporation will be found by moving vertically up to the top or 34.5 lb. line and interpolating on this line the scale graduated by the diagonal lines indicating lb. steam per lb. coal. Thus the relation of the actual to the equivalent evaporation for any condition is graphically apparent.

The uses of this diagram are numerous. Thus, if 72 per cent efficiency were being obtained with coal containing 14,000 B.t.u. per lb. costing $5.50 per ton at a unit cost of 0.91 cents per boiler horsepower-hour and if equally satisfactory furnace conditions could be obtained by the use of more modern equipment giving 80 per cent efficiency with 12,000 B.t.u. coal costing $3.00 per ton at a unit cost of 0.525 cents per boiler horsepower-hour, the difference—0.385 cents—representing the possible saving, would be $3465, probably equal to the first cost of the new equipment alone in a year's time if the plant load averaged 300 hp. for 3000 hr. per yr., or 125 hp. for 7200 hr. per yr.

Stack Sprays for the Recovery of Fly Ash

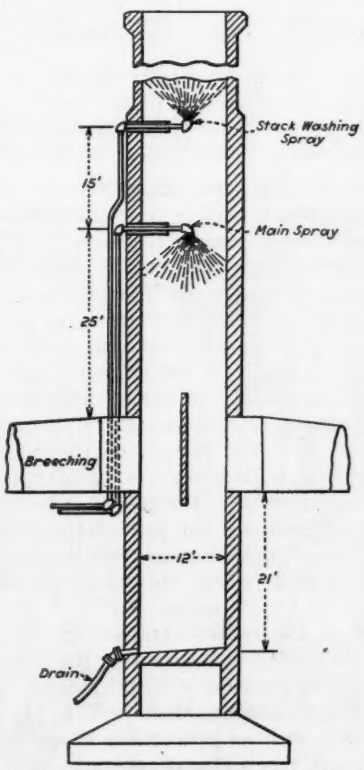
DETAILS OF INSTALLATION WHERE 5 TO 11 PER CENT OF COAL DISCHARGED AS SOLIDS FROM STACK AND SPRAY REMOVES ABOUT 35 PER CENT OF THIS. BY J. W. MACKENZIE*

IN ORDER to get a record of actual conditions resulting from the discharge of solids from the stacks of the Kalamazoo Station, the area surrounding the plant for a radius of about 12 city blocks was divided into sections. Each morning, a board about 16 in. sq. was placed near the center of each section, the upper side of the board having been freshly painted with white paint. Particles of dust settling on the board caught in the surface of the paint and formed a permanent record.

By watching the wind direction and comparing the record of each test coat of paint when the gases were passing over that district with the same test when the wind carried the gases in another direction, the relative effect of the stack discharge was determined. These records showed most objectionable deposits three or four city blocks from the plant. The deposits disappeared at a radius of about nine blocks.

To correct this condition immediately, it was decided to install a water spray in the concrete stack serving the boilers in the hope of washing out part of the solid material. This stack is 12 ft. inside diameter with a double breeching connection about 21 ft. above the stack floor.

A group of four spray nozzles located about 20 ft. above the top of the breeching connection and arranged to form a combined downward spray to fill the cross-section of the stack was first tried out. The results were rather better than was anticipated, but the pipe connections to the spray nozzles soon corroded and a single center spray with a capacity of about 30 g.p.m., when supplied with water at 10 lb. pressure, was substituted in an arrangement shown as the main spray in the illustration. This arrangement has the advantage that it can be inspected and repaired from outside the stack and operation has shown that when the spray covers the area of the stack, an increase in the quantity of water has but little effect on the results. Water and entrained ash were drained from the bottom of the stack into the sump of the ash-sluice system installed for handling the ashes from the plant, and discharged from the plant with the regular ash pumps.



ARRANGEMENT OF STACK SPRAYS

*Mechanical Engineer, Consumers Power Co., Jackson, Mich. Abstract of a paper presented before the A.S.M.E.

After about a week's operation, trouble was experienced due to flakes of accumulated fine ash coming from the stack and settling in the immediate vicinity of the plant. These deposits were confined to a radius of less than 500 ft. An investigation showed that an accumulation of this fine moist ash had collected in a circular band about 3 in. thick and extending from a point about 15 ft. above the level of the spray nozzle upward for about 3 or 4 ft. The moist ash gradually builds up at this point until it begins to flake off and is carried out of the stack.

This difficulty was readily overcome by installing a second, or stack washing spray, about 15 ft. above the main spray as shown in the drawing. This second spray is a duplicate of the main spray, but is turned upward so that the water from it strikes the wall of the stack at a point above the ash deposit. This water running down the stack wall washes the accumulation down. The use of this stack-washing spray about 20 min. a day is sufficient to eliminate all trouble from this source.

TABLE 1 HOURLY RESULTS OF TESTS

Test number	1	2	3	4
Number of boilers in use	2	2	2	1
Total lb. coal fired	23,183	17,711	16,888	11,644
Fly ash to stack, lb.	1,951	997	1,498	1,299
Fly ash recovered, lb.	756	624	463	437
Ratio, fly ash to coal, %	8.42	5.63	8.87	11.16
Carbon in fly ash, %	.....	49.0	35.9	40.4
Carbon in recovered fly ash, %	.....	46.2	37.4	46.8
Per cent of fly ash recovered	38.8	46.16	30.90	33.60

TABLE 2 FINENESS OF ASH

Test no.		Through 200	Through 100	Through 48	Through 28	Over 28
2	Total fly ash	62.7	81.2	95.6	99.6	0.4
	Recovered fly ash	43.6	62.3	91.2	99.6	0.4
3	Total fly ash	60.4	81.5	96.4	99.8	0.2
	Recovered fly ash	60.3	79.9	96.5	99.9	0.1
4	Total fly ash	47.4	62.5	95.1	99.8	0.2
	Recovered fly ash	53.2	71.1	96.0	99.8	0.2

TABLE 3 PER CENT CARBON AND FINENESS OF RECOVERED ASH

Test no.		Per cent carbon	Through 200	Through 100	Through 48	Through 28	Over 28
5	With spray	34.0	61.1	86.6	98.8	99.9	0.1
	Without spray	56.4	27.3	56.2	93.4	99.6	0.1
6	With spray	38.8	73.5	93.0	99.6	99.9	0.1
	Without spray	48.3	48.6	75.4	97.4	99.8	0.2

Some attempts were made to measure the per cent of material removed from the gases by the spray, but the breeching arrangement made it impracticable to obtain samples where the gases were traveling in a vertical direction and it was found that, due to a much higher concentration of solids at the bottom of the horizontal ducts, it was impossible to obtain anything like a representative sample or measurement of the solids under these conditions. The records obtained by means of the painted boards, however, indicated that, with the spray in operation, the amount of dust settling per square foot of area was not perceptibly different when the wind was carrying the gases from the stack over that district from that when the wind was in another direction.

In view of the results obtained at the Kalamazoo plant, it was decided to incorporate the same system in the design of the company's Wealthy Street plant No. 2 located at Grand Rapids, Mich. This plant is inside the city limits and no complaints have been received after about one year's operation.

Results of tests made in this latter installation are shown in the accompanying tables. They represent conditions from about three-quarters of normal boiler capacity to full normal capacity. The ratio of fly ash to coal fired is undoubtedly much lower with the reduced velocities at lower ratings, but no satisfactory data have been obtained at these lower ratings due to difficulty with the solids settling on the breechings.

Under the conditions covered by these tests, the ratio of the fly ash to the total coal varies from about 5½ to 11 per cent of the coal used. With the spray in operation, about 37 per cent of this amount is recovered. The tests show that under normal operation with the stack spray in use there is still about 5 per cent of the total weight of the coal discharged from the stack.

Average velocity of the gases in the stack under normal full load has been determined to be about 1000 ft. per min., with a volume of 127,500 cu. ft. per min., which gives a loading of about 0.156 lb. of solids per 1000 cu. ft. of gas. Of these solids more than 65 per cent will pass through a 100-mesh screen, a loading and fineness which apparently give sufficient dispersion to avoid detection.

Tests were also made to determine the per cent and relative fineness of the solids which would be deposited in the stack without the use of the spray. These tests show that with the spray in operation from three to four times as much material is recovered as without it. The spray also greatly increases the recovery of the fines, and is much more effective on the ash than on the carbon in the gases.

Effect of Water on the Stack

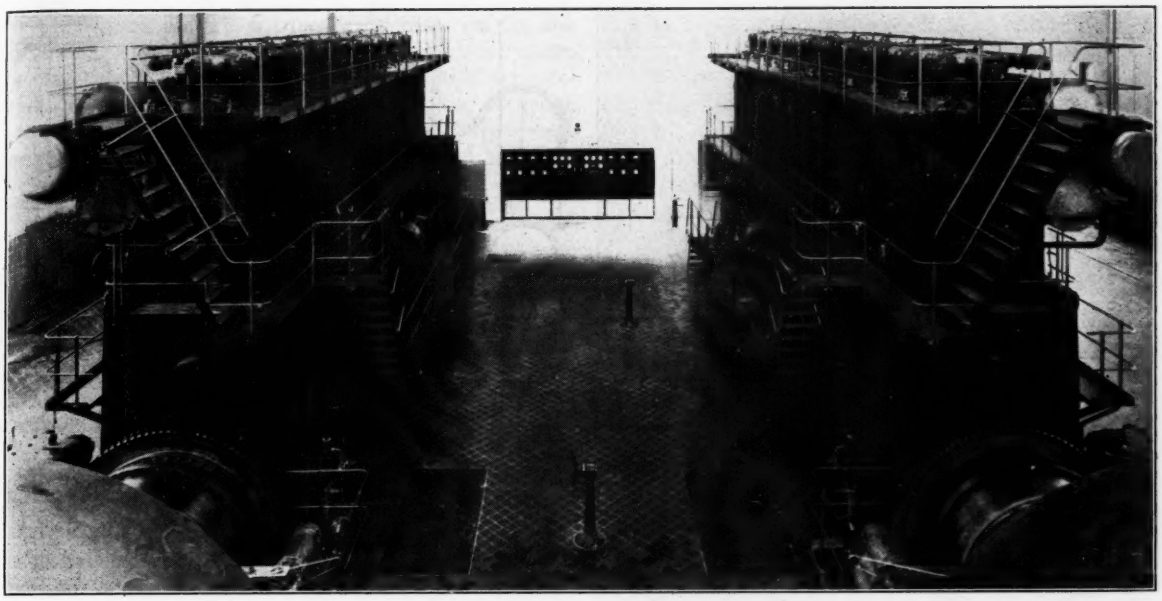
After about nine months' operation, an inspection of the inside of the Kalamazoo stack showed that the concrete surface was being seriously eroded by the use of the water. The effects were most marked at the bottom of the stack, diminishing in an upward direction.

While the spray had originally been installed only as a temporary measure, it was decided best to keep it in operation after all firing troubles were corrected. Accordingly an acid-resisting lining was installed extending from the base of the stack to a point about 50 ft. above the spray. This lining is constructed from vitrified tile laid with thin joints with an acid-resisting cement; a similar lining extending the full height of the stack was installed in the stack at the Grand Rapids plant and to date these lining are showing no signs of erosion.

From the experience, it appears that where a spray is to be used in a stack for removing fly ash from flue gases, the spray should be installed at least 20 ft. above the point where the gases enter the stack and that there should be a distance of at least two stack diameters from bottom of breeching connection to bottom of stack.

From the data obtained thus far, it appears that, provided the gas velocities do not exceed approximately 1200 ft. per min., a spray in the stack of a pulverized-fuel installation can be used as one means of reducing the fly ash discharged, and that a recovery of about 35 per cent of the solids can be expected. The use of larger quantities of water offers no advantage provided the spray covers the cross-sectional area of the stack. Means must be provided for periodically washing down accumulations of ash which will collect on stack wall above the spray. An acid-resisting lining is necessary to protect the interior of the stack.

It appears that reducing the dust loading of the gases increases their carrying power, thus increasing the dispersion.



Two 11,700-Hp. Diesel Engines Carry Peak Loads

LARGE DIESEL ENGINES INSTALLED IN BERLIN ARE CHARACTERIZED BY COMPACTNESS, SIMPLICITY OF DESIGN AND EFFECTIVE SCAVENGING. BY F. JOHNSTONE TAYLOR

SUCCESS OF the 15,000-hp. M.A.N. Diesel engines installed for peak load service at the Neuhof station at Hamburg, Germany, warranted the installation of two 11,700-hp. Diesel engines, which were built by the M.A.N. Co. of Augsburg, at the Heningsdorf peak load station in Berlin. While these sets have been run for only about 2 hr. each day and never on full load for more than 1 hr., they have been instrumental in improving, greatly, the load factor of the power station and on several occasions the plant has proved extremely useful as an emergency set, particularly in cases of stoppage at the main power station or in case of sudden demands due to fog. A view of the Berlin engines as installed, which indicates their simple design and relative compactness, is shown in the headpiece of this article.

Following, in the main, the standardized M.A.N. design for double-acting, two-stroke-cycle, airless-injection engines, each engine is equipped with ten 23⅝ by 35½-in. cylinders and they operate at 214 r.p.m., which

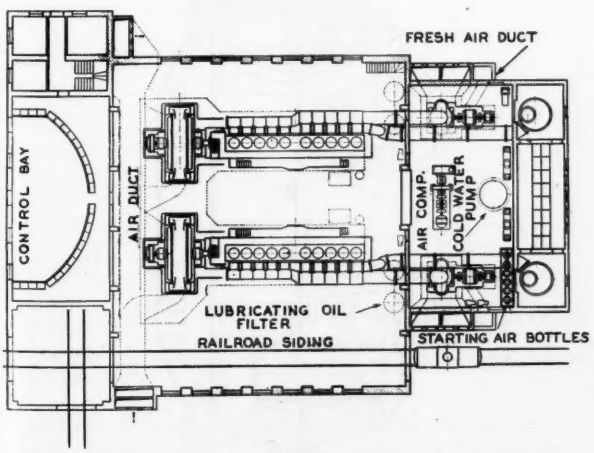


FIG. 1. GENERAL PLAN OF STATION SHOWING RELATIVE LOCATIONS OF THE TWO 11,700-HP. M.A.N. ENGINES AND AUXILIARY APPARATUS

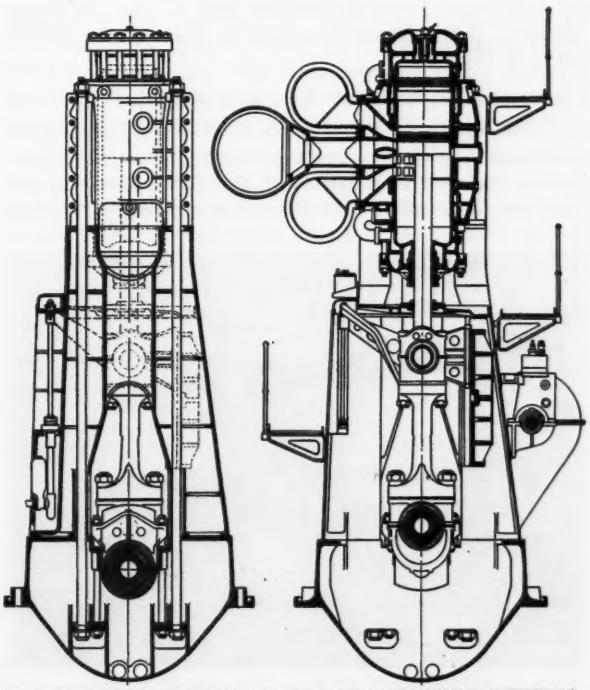


FIG. 2. CROSS SECTIONS OF ENGINE SHOWING GENERAL CONFORMANCE TO STANDARDIZED M.A.N. DESIGN

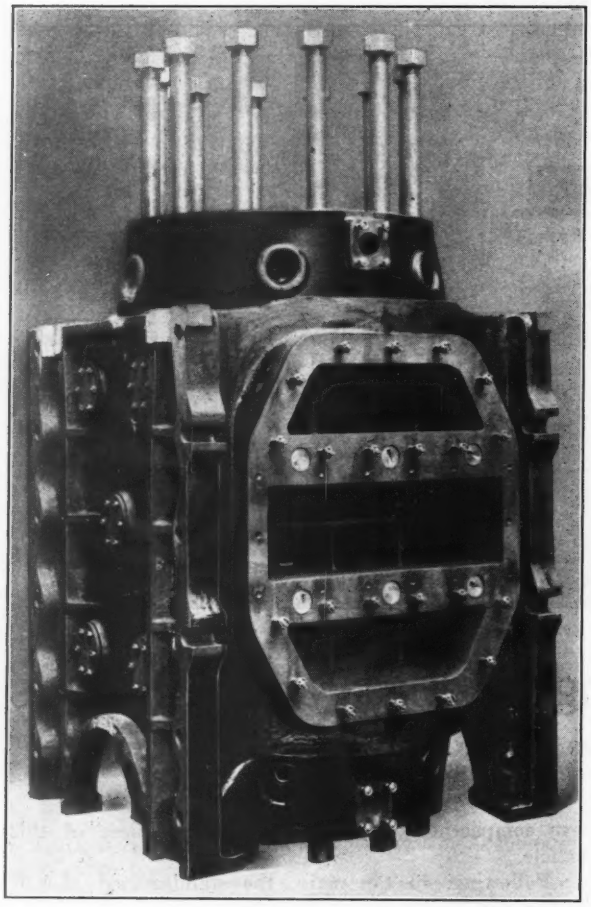


FIG. 3. ENGINE CYLINDER, SHOWING SQUARE CONSTRUCTION AND THE CENTRAL EXHAUST PORT BELT

is more than twice as fast as that of the Hamburg engines. The generator output of each of the Berlin units is 7500 kw.

Generators Used As Phase Regulators

After use in the morning hours to deal with the early peak load, the engines are disconnected from their generators through couplings and the two generators are then run in parallel with the steam alternators serving as phase regulators, until the engines are started up again to carry the evening peak load.

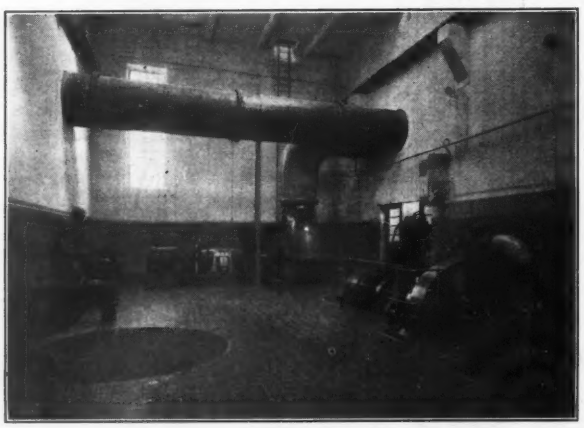


FIG. 4. MOTOR-DRIVEN, TURBINE BLOWER SUPPLIES SCAVENGING AIR TO ENGINE

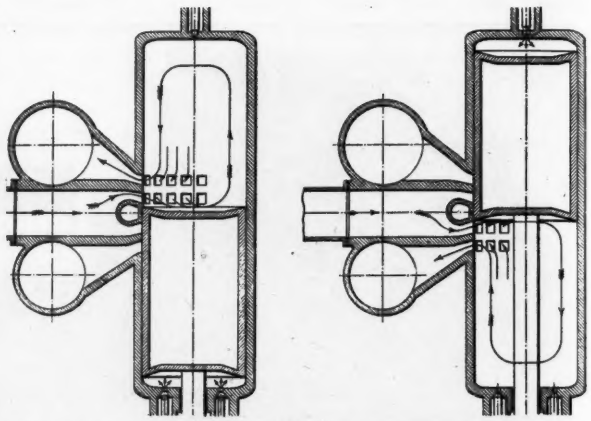


FIG. 5. SCAVENGE SYSTEM SHOWING DOUBLE SETS OF SCAVENGE AND EXHAUST PORTS AND METHOD OF SCAVENGING THE CYLINDER

Special attention has been paid to the cooling of the cylinder liners and heads. For this purpose, the liners have been kept as short as possible so that the combustion space is surrounded only by the cylinder heads. Simplicity in design of these heads is illustrated in Fig. 2. The mean indicated pressure is 90 lb. and the highest temperature, at the hottest part of the liner, does not exceed 266 deg. F. The central exhaust belt, which always presents a difficult problem in the case of 2-cycle, double-acting engines, is shown in Fig. 3.

Two Sets of Exhaust and Scavenge Ports Used

Scavenging air is supplied by the motor-driven, turbine blower shown in Fig. 4. There are two separate rows of scavenge ports in the center of the cylinder and one row of exhaust ports toward the outer ends on each side, thus forming one set of scavenge and exhaust ports for the upper part of the cylinder and another set for the lower part as shown in Fig. 5. The general direction taken by the scavenging air is shown by the arrows in the diagram. Near the end of the stroke, the exhaust

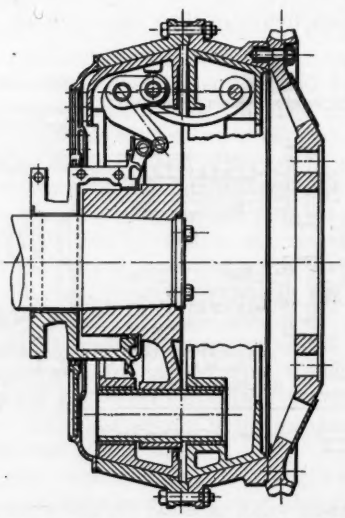


FIG. 6. CROSS SECTION OF BEMAG COMPRESSED-AIR TYPE OF COUPLING

ports open first, then the scavenge ports open to admit the scavenging air which, due to its direction by the ports and piston head, is sent to the cylinder head where its direction is reversed as shown. With this arrangement, the loss of stroke necessitated by the scavenge ports is 25 per cent for the lower side and 23 per cent for the upper. The auxiliary power required to admit the scavenge air is 9 per cent of the total horsepower.

Compressed-Air Type Coupling

Perhaps the most interesting feature of these power units is the coupling between the engine and generator, shown sectionally in Fig. 6. It is of the Bemag compressed-air type and is operated from the starting system which is under control at the switchboard. By a simple turn of the handwheel, air is admitted to the lower ends of five cylinders on each engine, the air delivery being timed by cam-operated valves. When the engines have attained a speed of 40 r.p.m., the starting air is cut off automatically and ignition commences. Starting may be accomplished in less than 3 min. time.

In the operation of the coupling, air acts on two oil-filled cylinders which transmit the pressure to operate the main pressure cylinder and by means of a cross lever and collar, the horizontal motion is transmitted to the internal members of the clutch. The outer casing, which carries the worm wheel, is made in halves, the driving portion being attached to the engine coupling. The casing, which is of a double-coned form, has internal-friction drums which are spring controlled and the clutch, in addition to serving as a flexible medium to damp out torsional vibrations, will slip when the turning moment becomes excessive. This slippage property is adjustable.

Improved Circuits for Feeder Voltage Regulator

TWO SINGLE-PHASE induction feeder voltage regulators are often used in a bank of two for the regulation of a 3-phase, 3-wire circuit. One of the

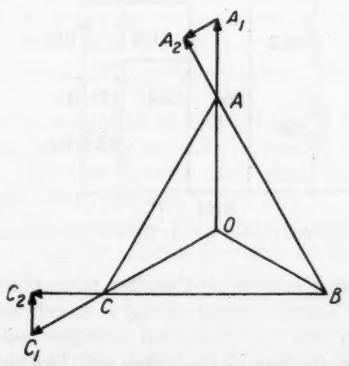


FIG. 1. VECTOR DIAGRAM SHOWING CURRENT RELATIONS IN REGULATOR CIRCUIT

AB, BC, CA represent the line voltages. OA, OB, OC represent line current at unity power factor.

conditions for maintaining the correct voltage at the center of distribution is that the current in the line drop compensator is of the correct power factor in relation to the line-to-line voltage. The line current of a 3-phase, 3-wire circuit is 30 deg. out of phase with the line-to-line voltage when the power factor of the system is unity. Under this condition, the current in the compensator would be 30 deg. out of phase with the voltage obtained from the secondary of the potential transformers if one current transformer is used with each compensator. In order to correct this, it has been standard practice for many years to use three current transformers with the two regulators, the secondaries of the current transformers being interconnected so as to correct the phase angle in the compensator circuits. This also resulted in a total current of 8.7 amp. in each compensator, using three standard current transformers with 5-amp. secondaries.

Modern outdoor type regulators are usually equipped with current and voltage transformers mounted inside

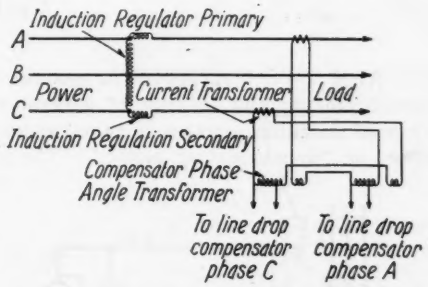


FIG. 2. DIAGRAM OF CONNECTIONS

the outdoor hood. The use of three current transformers for this type of installation thus made it necessary for the purchaser to mount the extra current transformer separately from the regulators or else purchase a specially designed regulator with two current transformers mounted inside the hood.

Recently a new scheme of connections, which has eliminated the need for the third current transformer has been developed by the Westinghouse Electric & Manufacturing Co. This is accomplished by using a small phase-shifting current transformer in the secondary of the current transformer circuit for each regulator.

In the vector diagram above, A-A1 represents the ampere-turns in the phase-shifting transformer (Compensator Phase-Angle Transformer) due to the current of the current transformer in phase A. A1-A2 is the ampere turns in the phase-shifting transformer due to the current from the current transformer in phase C, the ratio of turns in the phase-shifting transformer being 2 to 1 so that the ampere turns are of the proper magnitude. The phase relation of the current flowing through the compensator of the regulator in phase A is shown by A-A2, and it is to be noted that this is in phase with the line voltage AB. The magnitude of the current in the compensator (5 amp.) is determined by the number of turns employed.

This phase shifting transformer or Compensator Phase-Angle Transformer, as it is usually called, can be made quite small as it need be insulated only for the secondary circuit and its volt-ampere burden is very small. It may be a separate transformer which can be mounted conveniently on the rear of the standard regulator accessory panel, or it may be incorporated as part of the compensator.

Automatic Control of HYDROELECTRIC STATIONS *by the* All Relay System

Conditions Existing in the A.C. Circuits Which Change Frequency and Establish Synchronism Prior to the Closing of the Circuit Breakers.

Part III

by E. H. Stivender

THERE ARE TWO METHODS in general use for the synchronizing and loading of generators, they are, by "speed matching" motors and the "speed changing" motor, or "synchronizing motor." The all-relay

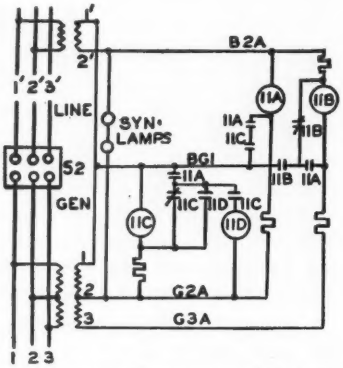


FIG. 6. CONNECTIONS OF FREQUENCY MATCHING RELAYS IN THE A.C. CIRCUITS OF THE CONTROL SYSTEMS

system employs the speed changing motor in connection with the necessary relays for automatically reversing in order to establish the machine frequency and phase relation in synchronism with that of the line and for automatically taking on load after the closing of the circuit breaker.

Part I of this article dealt with the action of the various control devices when starting the machine and Part II with the stopping cycle and protective devices. This installment describes the conditions existing in the alternating current circuits which change the frequency and establish synchronism prior to the closing of the circuit breaker.

The speed changing motor is a small 48-v. series motor possessing two field sections, the direction of rotation depending upon which section is in series with the armature. In parallel with the armature circuit, a 50—200 ohm radio rheostat is provided (Figs. 3 and 7): by manipulation of this rheostat any desired motor speed can be obtained thereby adjusting the motor speed in accordance with the characteristics of the governor mechanism.

By its action of increasing or decreasing the strength of the speeder spring operating the governor pilot valve, the operation of the speed changing motor increases or decreases the speed of the machine. It is controlled by a hand control switch CS2 (Fig. 7) as well as by the automatic frequency matching relays 11A, 11B, 11C, and 11D (Fig. 6).

In Fig. 6 is shown schematically the connections of the frequency matching relays in the alternating current circuits of the control system. This diagram omits all devices not directly bearing on the opening and closing sequence of these relays. Figure 7 illustrates the connections of the speed changing motor. From Fig. 6, it is seen that the synchronizing transformers on num-

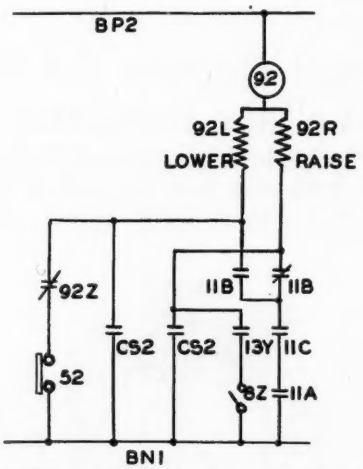


FIG. 7. CONNECTIONS OF SPEED CHANGING MOTOR

ber one phase are connected similar to standard practice for manual synchronizing using a synchroscope; that is, like polarities are connected together and the indicating lamps are across the other two like polarities, so that when the machine is in synchronism with the line the voltages across the lamps will be equal and opposite, resulting in the "dark" period or zero voltage. The same open-delta connected transformers are used for furnishing machine potential as are supplied for driving the governor fly-ball motor.

Relay 11A is connected similarly to the synchroniz-

ing lamps (2′ to 2) that is, for zero voltage at synchronism and double voltage at 180 deg. out of synchronism. This relay has 600 ohms resistance in series with its coil and is set to close at 135 v. and open at approximately 100 v. Relay 11B has 600 ohms resistance in series which is in 200 and 400 ohm sections, being also set to close at 135 v. It is connected to lead 2′ on the bus side of the circuit breaker and 3 on the machine side. Relay 11C is a "set-up" relay, set for closing at approximately 80 v., it is connected across leads 1 and 2 of the generator potential transformers. Relay 11D is a time element relay connected to close at approximately 60 v.; it is energized from leads 1 and 2 by the closing of 11A and 11C. 11A, 11B and 11C are Westinghouse type "MC" instantaneous multicontact relays with glass covers. 11D is a Westinghouse type "CV" induction time element over voltage relay.

By observing Fig. 6, it can be seen that if 11A closes while 11B is open 11B cannot close, regardless of the voltage impressed across its terminals owing to

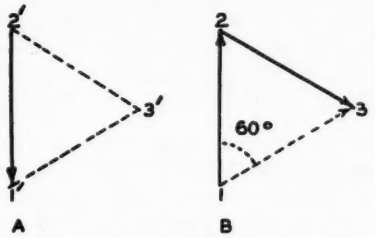


FIG. 8. PHASE RELATIONS

its coil being shunted by the "make" contacts of 11A and the "break" contacts of 11B. Should 11A close while 11B is closed, 11B cannot open, even though the voltage from 2′ to 3 (or bus B2A to G3A) shall become zero because its coil is held energized by the constant potential of B2A to BG1 through "make" contacts of 11A and 11B. Set-up relay 11C is closed as long as 11A and 11D are open but its coil is shunted when 11D closes, causing it to open. Time element relay 11D is energized through "make" contacts of 11A and 11C, it will open when 11A opens due to a change in speed or when 11C opens due to the closing of 11D.

By Fig. 7 it is seen that the circuit of speed changing motor 92 is closed through contacts of 11A, 11B and 11C. When 11B is open the "raise" field is energized and when 11B is closed the "lower" field is energized.

The vector diagrams of Figs. 8 and 9 illustrate the voltages impressed on the coils of relays 11A and 11B at various different speeds and phase angles of the machine relative to the line.

In Fig. 8a is shown the relative phase angles of phases 1′, 2′, and 3′ on the bus side of the oil switch. Since there is only one single phase transformer used and it is connected between lines 1′ and 2′ (constituting No. 1′ phase) vector 1′—2′ is drawn heavy and 2′—3′ and 3′—1′ are shown dotted, giving their relative phase angles on the power buses. In Fig. 8b is given the vectorial relations of phases 1—2, 2—3 and 1—3 of the secondaries of the open-delta connected potential transformers on the generator side of the circuit breaker. Since we are concerned with No. 3 lead only so far as phase 1′ is affected, the dotted vector 1—3 is shown. This vector is the sum obtained by the vectorial addition of the voltages between leads 1—2 and 2—3 and must not be confused with phase No. 3 of the power current which is 180 deg. displaced from it and corresponds to a different winding of the machine entirely. Also leads 1 and 2 and 1′ and 2′ constitute numbers 1 and 1′ phases, number 2 lead carries current of number 1 phase in the opposite direction or 180 deg. from number 1 lead. Number 2 phase is used in the operation of the

Owing to the connection of the transformers on power leads 1—2 and 1′—2′ the voltage 1′—2′ across

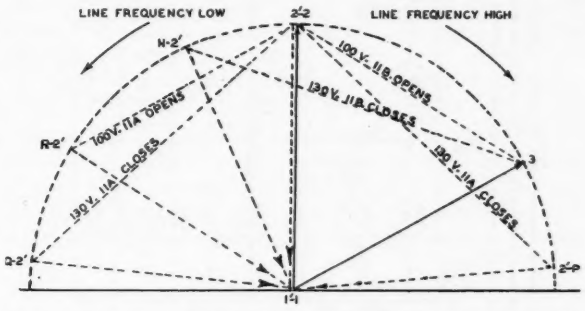


FIG. 9. DIAGRAM FOUND BY SUPERIMPOSING FIG. 8a ON 8b

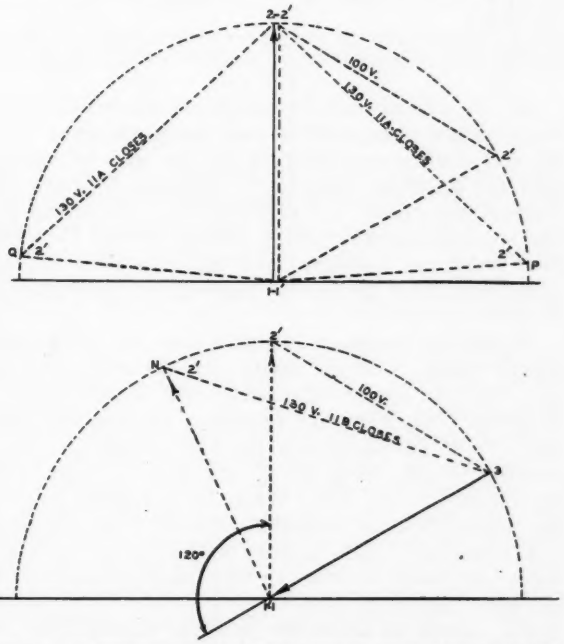


FIG. 9a. METHOD OF ILLUSTRATING VOLTAGES ACROSS 11a AND 11b BY ASSUMING AN ANGLE OF 120 DEG. BETWEEN 1—2 AND 3—1

In the upper figure only 1—2 and 1′—2′ are shown. In the lower, only 1′—2′ and 3—1 are shown. The direction of vector 1′—2′ are opposite in the two diagrams. This method though being more correct requires two diagrams to show the same values as Fig. 9. Note that the angle between 1—2 and 3—1 is 120 deg. instead of 60 deg. as in Fig. 9, 3—1 being reversed in direction.

11A at synchronism is equal and opposite to that of 1—2 hence the direction of vector 1′—2′ is shown opposite in Fig. 8a to the direction of vector 1—2 in Fig. 8b, therefore since all voltages concerned are of the same circuit we can superimpose Fig. 8a on 8b and form Fig. 9 in order directly to obtain the resultants of voltages 1′—2′ to 1—3, also 1′—2′ to 1—2. All points 1 can be considered the center around which the three vectors rotate. 1′—2′ is shown dotted in Fig. 9 and

parallel to 1—2 (in reality they directly coincide but both must be illustrated for simplicity). 1—3 is 60 deg. from 1—2 and 120 deg. from 1′—2′ so a chord drawn across the points 2′ and 3 represents the voltage across relay 11B (Fig. 6). For simplicity, if 100 v. is the voltage represented by vectors 1—2, 1—3 and 1′—2′ then the vector 2′—3 is 100 v. This is the resultant of voltages 1′—2′ and 1—3.

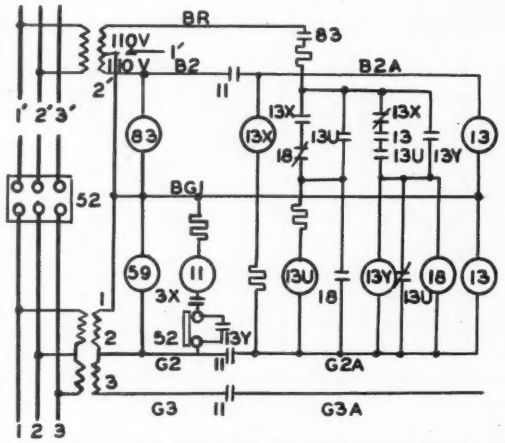


FIG. 10. SCHEMATIC DIAGRAM OF SYNCHRONIZING APPARATUS WHICH OPERATES TO CLOSE CIRCUIT BREAKER

Now, since only relative speeds are concerned, either the generator phase relation may be considered as moving and the line stationary or the line may be moving with the generator stationary. In order to make the diagram more clear, the vector 1′—2′ representing the line is considered as rotating around vectors 1—2 and 1—3 which are stationary and maintain their 60 deg. phase angle from one another regardless of their relation to 1′—2′.

If the line frequency is higher than that of the generator, vector 1′—2′ will rotate in a clockwise direction and if it is lower, this vector will rotate counterclockwise. When the line frequency becomes relatively high, 1′—2′ rotates toward point 3, voltage 2′—3 decreasing to zero when 1′—2′ and 1—3 coincide, now the voltage 2′—2 is 100. When 1′—2′ reaches point P the voltage 2′—2 is 130 and 2′—3 is 40, therefore relay 11A closes and 11B remains open, causing the synchronizing motor to rotate in the "raise" direction. If the speed difference is not great, vector 1′—2′ rotates slowly enough to allow 11D to close, locking 11D out before 11A opens or as vector 1′—2′ reaches point R. Now it can be seen that as 1′—2′ moves around to R, the voltage 2′—3 will increase to 200 v. but 11B cannot close and reverse the motor because its coil is shunted by contacts of 11A. Should 1′—2′ rotate rapidly, corresponding to a great difference in the relative speeds of the generator and line, the motor will be energized at more rapid intervals.

If the relative frequency of the line is lower than that of the generator, vector 1′—2′ will rotate counterclockwise, the voltage 2′—3 reaching 130 at point N and causing 11B to close, on reaching point Q voltage 2′—2 becomes 130 and relay 11A closes locking 11B closed and causing the motor to rotate in the "lower" direction. 11C and 11D perform in the same manner as for increasing the machine speed.

To the reader, it is no doubt evident that the foregoing method of obtaining the 60-deg. relation between vectors 1—2 and 1—3 is artificial, and although the voltages across the relays check with the values obtained by assuming a 60-deg. angle, it is nevertheless not rigidly correct. For this reason, it might be well to add the following method of description which follows the natural rules of vectorial representation.

When two machines are to be paralleled by means of a common bus, the voltages across the synchronizing oil switch must be opposing relative to one another, and of equal magnitude, before the switch is closed. If the bus is already energized from some outside source, such as another machine or incoming line, the voltages on either side of the synchronizing oil switch are in the *same* direction relative to the bus. If the direction of two voltages between any two corresponding lines on each side of the oil switch are alike relative to the bus, it follows that they are alike relative to the remaining lines, or phases (on either side of the oil switch). To make proper diagrams which follow the natural conditions of the forces present across the relays, it would be necessary to use two separate illustrations as in Fig. 9a. In one illustration, only the vectors 1—2 and 1′—2′ would be shown, 1′—2′ being opposite

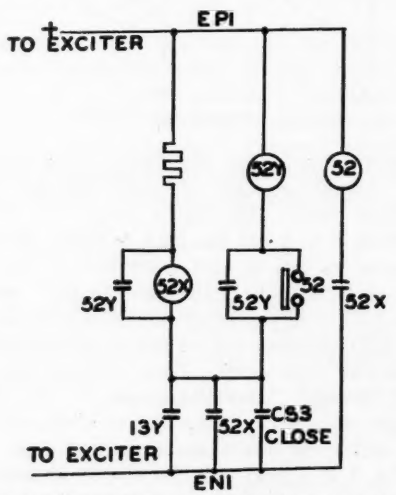


FIG. 11. DIAGRAM ILLUSTRATING AUXILIARY CIRCUIT BREAKER CONTROL

to 1—2, as in Fig. 9, at the point of synchronism and rotating around the point 1, the resultant voltages being represented by chords between 2 and 2′. In the other illustration, only the vectors 1′—2′ and 3—1 would be shown. (Vector 3—1 being opposite in direction to that shown in Fig. 9 for vector 1—3). Also vector 1′—2′ would be shown reversed, that is in the same direction as vector 1—2 in Fig. 9. In this manner, the same voltage values will be obtained for the relays as indicated in Fig. 9, the difference being that vector 3—1 takes its true 120-deg. position relative to 1—2 and two diagrams would take the place of Fig. 9, vector 1′—2′ being shown in opposite directions for each.

To place all vectors on one diagram in order to read correct voltages directly, vector 1—3 is reversed, producing an "artificial" 60-deg. angle as in Fig. 9.

Note from the foregoing that the direction of the synchronizing motor depends upon which relay (either

11A or 11B) closes first, this depending on whether the frequency should be increased or decreased; also that the greater the difference in frequency the more rapidly will the synchronizing motor tend to lessen it.

The device 13 which functions to close the circuit breaker at the proper time is an Allis-Chalmers synchronizing relay; it consists of two small 4-pole synchronous induction motors mounted on a base with their shafts in line, one shaft has a Micarta disc, on the face of which are mounted four contacts at 90 deg. angles (corresponding to the field poles). On the end of the other motor shaft and adjacent to this disc is another Micarta disc with one brush arranged to bear upon the four contacts, a spring being provided to give the necessary pressure. The two discs being concentric can be revolved independently and the contacts and brush, owing to their relation to the motor poles, will close a circuit between the two discs at one interval which corresponds to synchronism of the machine and line, and another interval corresponding to 180 deg. from synchronism; this is evident from the fact that the motors have 4 poles, the field poles having no permanent polarity, and there being four positions of the 4-contact disc at which contact is made with the brush of the one-contact disc.

Figure 10 is a schematic diagram of that part of the synchronizing apparatus which operates to close the circuit breaker. The complete diagram is shown in Fig. 2 of the first installment of this article. In Fig. 7 are illustrated the contacts (13Y) which cause the machine to assume load. Relay 11 closes when the machine has built up voltage. 83 is the "dead line" relay which opens its contacts if the line should become de-energized.

Therefore when the machine voltage builds up, the synchronizing buses B2A, BG1, G2A and G3A are energized due to 11 closing, and when the phase angle between the machine voltage and line voltage approaches 180 deg., the "make" contacts of induction time element voltage relay 13X close, completing the circuit of instantaneous relay 13U through the "break" contacts of 18, and make contacts of 83. 18 is an induction time element voltage relay and is de-energized at this time; but 13U will not close because the voltage between lead BR and G2A approaches zero as the 180-deg. angle is neared, it closes when this angle is passed and is nearing the zero degree angle (when the machine is in synchronism with the line), at which time the "make" contacts of 13X are open but 13U is locked in by an auxiliary contact 13U which shunts contacts 13X and 18. If the phase angle is changing too rapidly for the circuit breaker to be closed, the operations described above will be repeated. When the phase angle approaches zero slowly enough to allow time element relay 13X to close its "break" contacts (at 60 v.) and the contacts 13 of the automatic synchronizer are closed, the machine is approaching synchronism slowly enough to allow the circuit breaker to be closed; therefore the circuit of circuit breaker closing relay 13Y is completed from BR through 83, 13X, 13, 13U coil 13Y to G2A.

Referring to Fig. 11, 13Y contacts complete the circuit of auxiliary circuit breaker control relay 52X which energizes the closing solenoid 52 from exciter current. As the breaker closes, trip-free relay coil 52Y is energized shunting coil 52X, and opening the circuit of 52. Should the breaker fail to remain closed for any reason, 52Y will still be energized through its auxiliary contact, preventing reclosure until the machine is again synchronized.

The instant 13Y closes, the speed changing motor 92 starts revolving in the "raise" direction (Fig. 7) and time element relay 18 starts, when its contacts close coil 13U is shunted, which on opening shunts coil 13Y. An auxiliary "make" contact of 13Y opens the circuit of 11, thereby deënergizing the synchronizing buses until the opening of the circuit breaker at some future time; hence the amount of load taken is proportional to the time setting of 18.

In order further to illustrate the action of synchronizing relay 13, the diagram Fig. 12 is shown. This represents the character of the voltages impressed on the coil of relay 13X just before and at the time the breaker closes. The curves represent magnitude of voltage plotted against time, and must not be confused with alternating-current waves representing polarity. Voltage is shown by ordinates "C" and time by abscissae marked "time". The shapes of these curves are taken from the different values of vector 2′—2 in Fig. 9 as vector 1′—2′ revolves around the point 1, the lengths of abscissae O—O (Fig. 12) are proportional to the time taken for vector 1′—2′ (Fig. 9) to make a complete revolution.

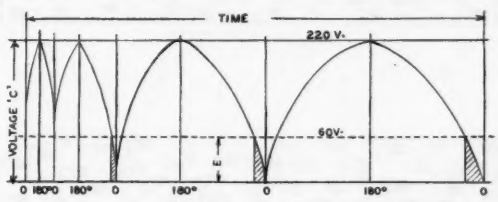


FIG. 12. ACTION OF SYNCHRONIZING RELAY

Each point marked "O" in Fig. 12 represents the instant when synchronism is reached. The line "E" represents the 60-v. line or the value at which 13X starts to close, the hatched area of each curve therefore indicates the bounds within which 13X is operative.

Starting from point "A" at the left of the diagram where the difference in frequency is relatively great, the tops of the voltage curves remain the same but the time increases making the sides of the second curve more gradual than those of the first. It can also be seen that the hatched areas become greater, and in the fourth curve this area is great enough (time in which there is 60 volts and less across 13X) to allow relay 13X to close. Now, owing to the fact that the two motors of 13 are synchronous (having definite poles), the poles of the motor on the machine side will exactly correspond to those of the motor on the line side when the machine is in synchronism with the line. Since there are four contacts on the disc, contact will be made both at the points on the curves marked "180 deg." and at those marked "O" but relay 13X will operate only at the points "O"; hence the circuit breaker can be closed only at point "O" on the extreme right of the diagram, that is when the machine is slowly passing through synchronism.

The foregoing system of automatic hydro station control was originated by P. M. Stivender and T. B. Montgomery of the Allis-Chalmers Mfg. Co.

Electricity---What It Is and How It Acts*

PART XLIII. FUNDAMENTAL IDEAS UNDERLYING MODERN THEORIES OF MAGNETISM. THE MAGNETON. BY A. W. KRAMER

ONE OF THE ESSENTIAL differences between phenomena of an electrical nature and that of a magnetic nature, is the fact that while it is a simple matter for us to charge at will any body either electropositively or electronegatively, we can not produce or so influence a body as to impose upon it a charge of either "positive" or "negative" magnetism only. We have seen that every magnet consists of two equally strong poles of opposite polarity. While electric lines of force may originate in one body and terminate in another, in magnetism, both the source and the terminus of the lines of force are always situated within the one and the same body. Although spoken of and useful theoretically, the "unit magnetic pole" is an impossible conception. There can be no free magnetic charges.

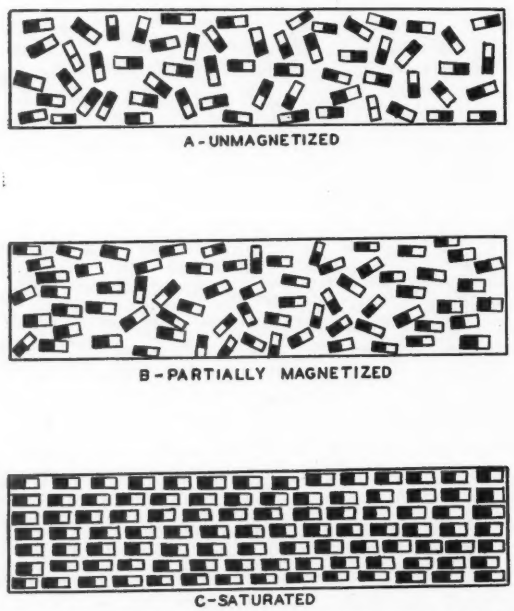


FIG. 1. DIAGRAM ILLUSTRATING FUNDAMENTAL CONCEPT OF MAGNETISM

A. Arrangement of molecules in a bar of unmagnetized iron. B. Arrangement of molecules in a bar of iron partially magnetized. A large number of the molecules, it will be noted, are arranged parallel to each other. C. In a "saturated" bar, the molecules are all parallel to each other and to the external magnetic field.

It is precisely this consideration of "polarization" as this property of having "poles" is called that has made it possible to regard magnetism, not as a separate phenomena but rather to correlate it with other phenomena, that is, with electrical phenomena. As we have learned[1] a wire coil through which a current is flowing displays those very characteristics which are peculiar to a magnet; closed magnetic lines of force arising at one end of the coil proceed through the air in circular fashion and terminate on the other end of the coil. While the current is flowing such a coil is virtually a magnet.

It was natural, therefore, to assume to explain magnetic phenomena on the basis of the phenomena observable in the neighborhood of current bearing coils and both Ampère and Weber advanced theories to that effect.

Ampère assumed that in each molecule of a magnetic substance there is an electric current flowing in a fixed channel. If these "molecular" current rings have unorganized directions, the body in question is exteriorly non-magnetic. If, on the other hand, a large number of these current channels are parallel to each other, the body will exhibit an external magnetic field.

It is evident that with this conception, we may formulate more or less crudely perhaps, but logically, a motion regarding the way in which a substance becomes magnetized. This was the basis of Weber's theory. He assumed that the molecules of iron or steel are tiny permanent magnets, capable of being turned around their centers. The ideas underlying Weber's hypothesis can be explained by means of a few simple diagrams as follows:

In Fig. 1A is shown an unmagnetized bar of iron, with the molecules represented by small rectangles. Each molecule is assumed to be a small magnet with its own north and south pole and, in this unmagnetized bar, are so irregularly arranged that they mutually neutralize each other's external fields. The north and south poles point haphazardly in all directions.

Upon the application of a small magnetizing force, such as produced say by induction from a small permanent magnet, the small magnets (molecules of iron) are acted upon by the field and tend to set themselves in line with the field of force. This condition is depicted in Fig. 1B. A large number of the molecules, it will be noted, have lined up and their north and south poles all point in the same general direction. The bar is now partially magnetized.

Suppose now, that the magnetizing force is still further increased, gradually more and more molecules set themselves in the direction of the field of force and the bar becomes more strongly magnetized. There is a limit, however, to the degree of magnetization which can be given to the bar, regardless of how strong the applied magnetizing force may be and this limit is reached when all the molecules are arranged in the direction of the magnetizing force. Under this condition, depicted in Fig. 1C, the iron is said to be saturated.

This hypothesis, although by no means complete as presented here, is more remarkable when we consider that the existence of such molecular magnets can be understood on the basis of our knowledge of the relation between electricity and magnetism, i.e., that a current ring produces a magnetic field.

At the time this hypothesis was first proposed, although it afforded a ready explanation for certain phenomena, it was nevertheless beset by a great difficulty—the *permanent* magnet.

*All rights reserved.

[1] Electricity—What It Is and How It Acts—Vol. 1, Chapter XIII.

It is easy enough to picture circulating currents in a body under the influence of a magnetic field since currents can be thought of as arising by induction. But in the case of a permanent magnet, it was necessary to assume the existence of molecular currents of constant value which, in electrical terms demanded circuits of zero resistance, that is perfect conductors.

A hundred years ago when Ampère first suggested molecular currents, such perfect conductors were contrary to the known properties of matter, but the modern theory of the atom, as has been shown, postulates the existence of such molecular currents as a basis for the theory of atomic structure. For, upon the basis of modern[2] theory, electrons are moving in closed orbits within the atom. Even though some of the more recent developments in atomic physics have questioned the physical reality of such revolving electrons or at least the mechanical explanation of such motion, we shall in this discussion retain this usual conception of the structure of the atom. As a matter of fact, it is precisely the magnetic phenomena which we are considering that give weight to the orbital theory of the atom—it may be regarded as direct evidence of the existence of such electronic orbits.

We have seen that the electron is the smallest "particle" or "division" of electricity that can exist. We can, therefore, adopt the *effect* of the revolving electron as the absolute unit or moment of magnetism. The electron is an atomic entity, the *magneton*, an atomic property.

Before we continue with a discussion of the absolute magnetic unit, let us follow Weber's theory of molecular magnets a little further to see just how far it is capable of accounting for some of the known facts of magnetism. We know already that it explained in a crude way the manner in which a substance becomes magnetized. The molecular magnets under the action of an external magnetic field aline themselves all in the same direction. The theory, however, did not explain why all the molecules did not come into line until the magnetizing force has reached a high value. Weber assumed that any displacement of the molecule was resisted by a restoring force which tended to restore the molecule to its original position, but this view was inconsistent with the observed phenomenon of residual magnetism and hysteresis.

Hysteresis

If a piece of iron is magnetized by placing it in a strong magnetic field, it will be found, after the magnetizing force is removed, that the iron retains some of the magnetism. To restore the iron to its original non-magnetic state, therefore, it is necessary to apply a magnetic field of force in the opposite direction. In other words, a negative magnetizing force must be applied before the iron is restored to its original non-magnetic state. This phenomenon can better be explained by means of a diagram.

In Fig. 2, the horizontal distance from the point O along XX′ represents the intensity of an applied magnetizing force, H; to the right of O the force is in one direction, to the left in the reverse direction. The vertical distance from the point O along the line YY′ represents the degree of magnetization of a bar of iron, under the influence of the magnetizing force H. Above the point O this magnetization is in one direction, below, in the opposite direction.

Assume now, that a bar of unmagnetized iron is subjected to a gradually increasing magnetizing force H in the direction of X′. The flux density (degree of magnetism of the iron) of the iron will increase gradually and when the magnetizing force A′ is reached, the flux density will be A″. If the magnetizing force is now decreased again from A′ to O, the flux in the iron will not decrease along the curve A-O, but will decrease less rapidly along the curve ab. When the point B is reached, the magnetizing force will be zero, but the iron still retains an amount of magnetism represented by the height of the ordinate OB. Before the magnetism in the iron can be reduced to zero, the magnetizing force must be reversed and raised to a value oc in the opposite direction.

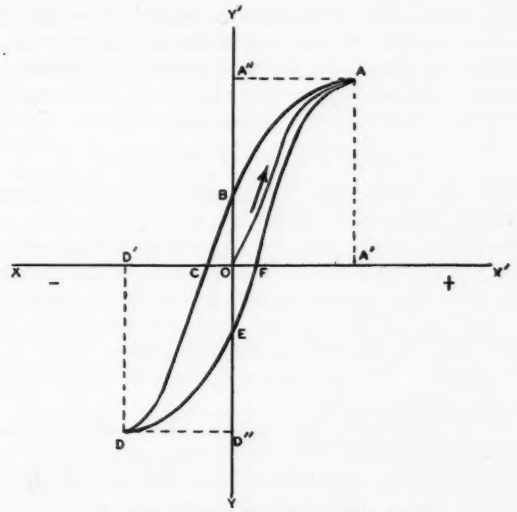


FIG. 2. THE HYSTERESIS LOOP

If now the magnetizing force H is still further increased in the negative direction, to a value D′, the flux density in the iron will reach a negative value D″. If the magnetizing force is now again decreased to zero, the flux density curve will pass through the point C, and to bring it back to zero value, the magnetizing force must again be increased in the positive direction to the value F. When the magnetizing force again reaches the value OA′ the flux density returns to its original value A″ along the curve FA, thus closing the loop.

Thus, it will be evident that the magnetization lags behind the magnetizing force. This tendency to lag is called *hysteresis* and the cycle of magnetization shown in Fig. 2 is called a hysteresis loop.

So much for the general phenomenon of hysteresis. As was stated above, while Weber's theory provided a logical explanation for the fundamental property of magnetism, it did not account for this lag of magnetism behind the magnetizing force.

A theory is of little value unless it can account satisfactorily for all known effects, so the Weber theory has undergone a number of modifications. It is evident, in considering Weber's views on magnetism, that no new "magnetic medium" enters into the discussion. Instead

[2]The Bohr Theory.

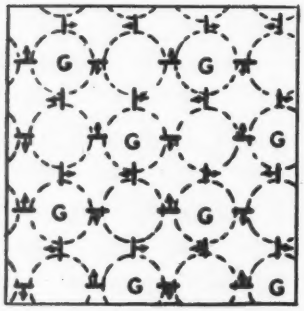


FIG. 3. ARRANGEMENT OF MOLECULES AND MAGNETIC FIELDS IN AN UNMAGNETIZED IRON BAR

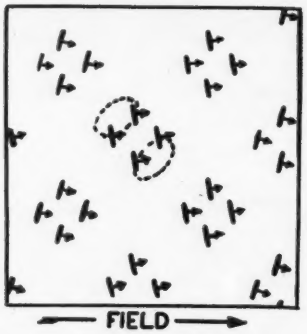


FIG. 5. ARRANGEMENT IN A STRONGLY MAGNETIZED BAR OF STEEL

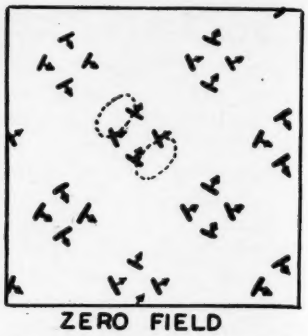


FIG. 6. ARRANGEMENT SHOWING REMANENT MAGNETISM IN STEEL

we merely assume a modification of our conception of the atomic or molecular structure of materials. The conception of molecular magnets, indeed, is an idea that fits in very well with our previous explanation of the structure of the atom, for if the atom is composed of electrons moving in closed orbits, it is to be expected that these orbits will exhibit magnetic effects.

Modern Theory of Magnetism

The view now held, is that each atom of a magnetic substance comprises a number of current rings and these current rings give rise to corresponding magnetic fields within the atoms. In a material in an unmagnetized state, the current rings will arrange themselves in stable equilibrium so that their magnetic fields form closed circuits and thus no magnetic effect becomes evident outside. The arrangement, probably, is something like that shown in Fig. 3.

In a substance like steel which has a definite crystalline structure, the atomic current rings are considered as being concentrated into compact groups with relatively large spaces between neighboring groups, as shown in Fig. 4.[3] This distribution does not imply any change in the average number of current rings in unit volume but merely that each group of current rings shown in Fig. 3 shrinks into each group shown in Fig. 4,

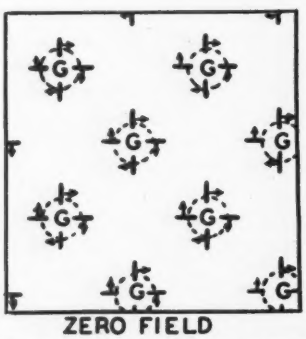


FIG. 4. STABLE GROUPING OF MOLECULES IN AN UNMAGNETIZED BAR OF STEEL

which represents the completely unmagnetized condition of the substance.

Suppose that a strong magnetizing force is applied to this steel. Each group of current rings will rearrange itself somewhat as shown in Fig. 5, so that the magnetic axes of the individual groups all have components in the direction of the applied force. After the removal of the magnetizing force, the current rings will return to some such stable arrangement as shown in Fig. 6 and this remanent arrangement of the current rings accounts for the remanent magnetism.

Thus it is evident that in accounting for magnetic phenomena it is unnecessary to introduce any radically new concepts or ascribe any fundamentally new property to matter. The idea of magnetisms requires merely an extension of our theories of atomic structure. Further considerations regarding the electron theory of magnetism will be discussed in a subsequent chapter.

Fire clays of the best grades are often associated with bituminous coal areas and lie in the veins in the same way. Sometimes they occur in secondary deposits where the original vein has been washed away and deposited in a new level.

They are a double silicate of alumina, usually hydrous silicate of alumina combined with silicate of certain other minerals. They are mined much the same as coal by drift, slope or shaft and in some cases by simply stripping off the overburden.

Flint clays are dense and tough, highly refractory and constant in volume over a wide range of temperature. Plastic clays contain a higher percentage of silica, are porous particularly when ground and are available as bond material.

Various refractory brick are produced by blending different clays after crushing and grinding. After tempering, the clay is molded, pressed, dried and burned. An analysis of one highly refractory firebrick shows an analysis about 52 per cent silica, 43 per cent alumina, two per cent ferric oxide, about 1.5 per cent each of titania and alkalis and some lime and magnesia.

With the hand-made process, the clays are crushed and ground and then molded by hand. They are tempered on a hot floor, pressed by hand, dried for about four days on a hot floor and burned in kilns.

With the stiff mud process, the clay is crushed and redried and fed by a pug mill through an extrusion machine and die forming a rough brick, which is repressed by hand or mechanically, dried and burned. In the dry press process, the clay after grinding and screening is fed by a mixing mill to a heavy press where the semi-moist clay is formed. It is then dried and burned.

[3]The Evershed Theory. Journal of the British Institution of Electrical Engineers, 1920, Vol. LVIII, page 780.

Is the Power House Part of Your Plant?

TOO OFTEN MODERNIZATION STOPS AT THE FACTORY; THE POWER HOUSE MUST GET ALONG AS BEST IT CAN. A STORY FOR FACTORY EXECUTIVES. BY K. RANKIN

FATE HAD BEEN KIND to James MacAndrew. Luck broke his way and soon after coming back from overseas, he found himself presented with a prosperous manufacturing business. It was running on its own momentum, making an added spurt when MacAndrew's Scottish instinct put some of the modern methods and equipment to work.

I hadn't seen Jim since we were mustered out in 1918 until we ran into each other accidentally one day. After exchanging notes, Jim insisted that I lunch with him at the club and go out and see the business. Jim hadn't changed much during these 13 yr., except for being a little bit older, a little bit harder, somewhat more alert and preoccupied. He had always been a live-wire and a money maker.

Luncheon and the 10-mi. drive out to the plant broke down that reserve which comes to men who have been separated for years. As we neared the plant, I noticed that the main building was modern, leaning to the aesthetic. The green lawn, bushes and an honest-to-goodness daylight plant came into view. In the background was what appeared to be an older section, for the various colors of the brick showed where extensions had been made from time to time, much as the rings on a tree tell its age.

THE OFFICE WAS CHEERFUL AND BUSINESSLIKE

The office was all that a modern office should be, bright, cheerful, quiet, businesslike. "We are located in a small town and 10 mi. from it," said Jim with pride as we looked around the office. "But we are right up to the minute." We passed by a closed room, lined with sound-deadening material so that the telephone operator would not be disturbed by noise. In addition to the switchboard, she was handling four electric typewriters, and yet none of their din escaped into the outer office. All the typewriters were noiseless, most of them motor-driven so as to cut down the foot-pounds of energy required by the stenos. There were several electrically-driven adding machines. The office was equipped with a permanent exhaust fan system to keep things comfortable. Over in the corner was installed an electrically-operated, drinking water cooler. The sales manager had a full line of steel visible files, so that he could obtain at a glance information covering any territory or any salesman's sales by weeks or months.

"The Army lost a good organizer when you got mustered out," I told Jim, as he pointed out the various pieces of modern equipment, practically everything being the last word in labor saving and noise reducing apparatus.

"Yes, we have the best equipment and everything is up-to-date," replied Jim, with pride, "you can't do good work without good tools. Nor can you meet 1930 competition with old equipment. We threw out all our old office equipment several years ago, most of it being the original furniture bought some 20 yr. back. We cleaned the whole thing out and started afresh.

THE FACTORY WAS KEPT UP TO DATE

"We've done the same thing in the plant," went on Jim as we went out into the factory. I noticed here and there belt drives where they were clearly the most satisfactory drive. The majority of machines, however, had individual motors. Ball-bearings predominated. Jim told me that their accident rate was practically zero, which was just about what I would expect, for the general lighting was ample for safety and cheerfulness, while individual lighting was furnished where needed. Machines were not extravagant of floor space, nor yet so crowded as to interfere with the handling of materials. All corridors and aisles were clear. The building was sprinkled, with fire equipment located at strategic points. Bulletin boards were located where men could not fail to see them and each carried large posters, well colored and expressive, pointing out the benefits of thrift, of loyalty and of carefulness. Here, also, were to be seen electrically-cooled fountains, so that the men could have plenty to drink without wasting much traveling time going to get it.

"There's not a machine in our plant more than 4 yr. old," Jim told me. "We buy all our equipment on the basis of performance. We plan our production a year in advance wherever possible and then tool up to meet our estimate. In this way, we have gone right through the present slump, at 98 per cent capacity. Our labor turnover is practically nil. Working conditions are good; the wages are in line with other wages around about this part of the country while the promise of steady work makes our people content and conscientious. They do not have to soldier on the job, afraid that if they work too fast that they will work themselves out of a job. We have no labor problem and nothing to fear from the Reds or Bolsheviks." We meandered into a recreation room, where the employes could also eat their meals. Individual lockers and a really refreshing wash room more like one of our modern hotels, enabled everyone to freshen up before going home.

"We're small but we're efficient," said Jim, as we went back into the office, the inspection trip completed. "And what about those other buildings I saw as we came in?" I asked. "I am interested in power plants and I noticed you had quite a tall stack out in the back, do you make your own power?"

"Yes," said Jim, "we use considerable steam and we are able, therefore, to make our current as a by-product. We have a nice little power plant, that never breaks down and that is saving us considerable."

"I'd like to go through your power plant, if I may," I said, because the power plant was more in my line than the factory and the office, although, of course, I

know a good thing when I see it. Turning about face, we went out the back to the power plant. Getting there was something like going over No Man's Land. I could see that friend MacAndrew did not travel this terrain very often. As we entered the plant, the man in charge came up to MacAndrew and told him that he was wanted on the phone at the office, so I was left alone to pay my respects to the power plant.

Tony, the fireman, was a conscientious cuss. He knew his onions, or rather his power plant. He had been on the job every day, except for his annual vacation since 1914, had never missed a day and had never been late in reaching the job or leaving it. Moreover, the power plant was just about the same as it was back in 1914, when Tony first came into it. I could not help thinking as I stood in the power plant, as having so recently stood in the office, that here met the ancient and modern, 1900 alongside 1930, an incongruous situation.

How some of these old power plants run! Never a breakdown, rarely a request for repair parts. They just run. The three boilers were installed in 1907 and each was still equipped with its original water column. Tony knew when the additional boiler was necessary, although he did not know how much steam any of the boilers were producing. All three boilers were hand-fired, and Tony had become skilled since he took hold back in 1914. Tony did not know exactly how much coal they burned a day or week, although he did know that they used about five truckloads of coal per week. He thought they were five-ton trucks. The coal was purchased from a local coal dealer. It was good coal, although sometimes they had to use a run of troublesome coal.

Tony Guessed the CO_2 Was About 12 Per Cent

Tony did not know what the CO_2 was but he guessed they kept it around 12 per cent. His judgment was sustained by Washington Williams, the man who did the firing and handled the ashes. A cursory inspection of the ash showed that the carbon content ran needlessly high while the cracks in the setting suggested that 7 or 8 per cent CO_2 was the most that could ever be expected.

About 25 per cent of the piping was not covered with insulating material. All flanges were bare. The two engines, of the Corliss type, were running like clockwork, smooth, silent, a sight pretty to see. The serial numbers on their name plates showed that they left the factory about 1904. That's one thing about Corliss engines, they never seem to wear out. In fact, the engines made less noise than the boiler feed pumps, and I told Tony so. "These here pumps have run everyday since 1907," said Tony with pride. "They're noisy all right, and talk back to yer sometimes. But they don't make pumps any better than these here pumps. And they don't make 'em like these pumps any more," said Tony. I could see that he had considerable affection for these feed pumps, steam eaters though they were.

As I strolled back to the office and Jim, I could not help figuring. Of course, as they made their power as a byproduct and used their steam, a little waste by the engines was not so bad. But I could not help thinking how much they would save if they used equipment of the efficiency that 1928 or 1930 has to offer. If they would only go over the boiler setting and put in modern stokers, there is no doubt that they could cut their coal consumption at least 20 per cent. Twenty per cent of 25 t. of coal per week would amount to about $780 a year, with coal costing $3 per ton.

Jim looked up as I entered his office. "Did you see all you wanted to?" he asked. "I hope you enjoyed yourself." I wanted to say a few words to Jim, but did not want to hurt his feelings, or injure the very real pride that he had in his business. I felt that he ought to know.

"I noticed that you have a good poster up in your plant, Jim," I said, "which says, 'A Good Start Is Half the Race.' Another old saying is that 'most people can start, but few know how to finish.' Jim, you are operating a boiler room that was up to par in 1904. It is 25 yr. out of date now and it's costing you real money. Do you know those boilers are 23 yr. old? Do you know you are using engines that were built away back in 1900? Do you know that you could save probably well over $1000 a year in your power plant by making minor changes here and there? Going from this office into your power plant is like going from New York or Paris into some of those little French villages where we used to camp . . ."

Out of Sight, Out of Mind

"I know our power plant isn't all it should be," replied Jim, a little weakly. "The truth is, I don't know much about power plants and I don't go over to it as often as I should. We want to get around to it pretty soon, because I know that what you say is true."

"Don't wait too long, that's all," I replied. "You have spent over $12,000 since 1914 on coal, that could have been spent in dividends. That's only a rough guess, but actually you have squandered more than that. Another thing, really more important, is that your entire factory here depends upon the power plant staying in business. You would not think of using typewriters or adding machines that are 15 or 20 yr. old in this office. How can you afford to use 23-yr.-old boilers and engines that are older when your entire factory and payroll depends upon dependable power?"

"The power plant has kind of haunted me for a long time," Jim said frankly. "I have let it drag because I hardly knew just what to do about it. I think that I just needed someone like you to give me a kick and make me ashamed of myself. It is the only thing around our property and in connection with our business that I cannot boast about. I have shirked the job of tackling it. Next week that is my big job and, come what may, I'm going to tackle it and see it through," He reached over to his desk pad to make a notation.

"Come around 6 mo. from now and you'll find that we have a power plant like our office, up-to-date, efficient, something of which we can be proud. Meanwhile, thanks a lot for starting something. Your visit today is going to save me thousands of dollars in the next few years, because I will see that our power plant gets a square deal."

Steel turbine foundations are now often favored for the larger units, because of the increased space available underneath the machine for air coolers, oil coolers, ejectors and bleeder heaters.

There is no chemical action between ammonia and iron.

Waterville—Highest Head Hydroelectric Plant in the East

OF THE HYDROELECTRIC plants to be completed this year, none has aroused greater interest than the Waterville development of the Carolina Power & Light Co. This incorporates the highest hydraulic head, 861 ft. gross, in use any where east of the Rocky Mountains, vertical reaction type main turbines and impulse type house unit, and frequently and load control equipment. A feature of the project is the flow line running State Line southward about 200 mi. through a broad belt which, in places, is more than 100 mi. wide. The company's total installed generating capacity exclusive of the Waterville Plant is 145,050 kw., of which the eastern division has 126,550 kw. The principal generating stations in the eastern division include the Norwood Hydroelectric Plant, 62,000 kw., which was placed in operation in 1928, the Blewetts Hydroelectric Plant,

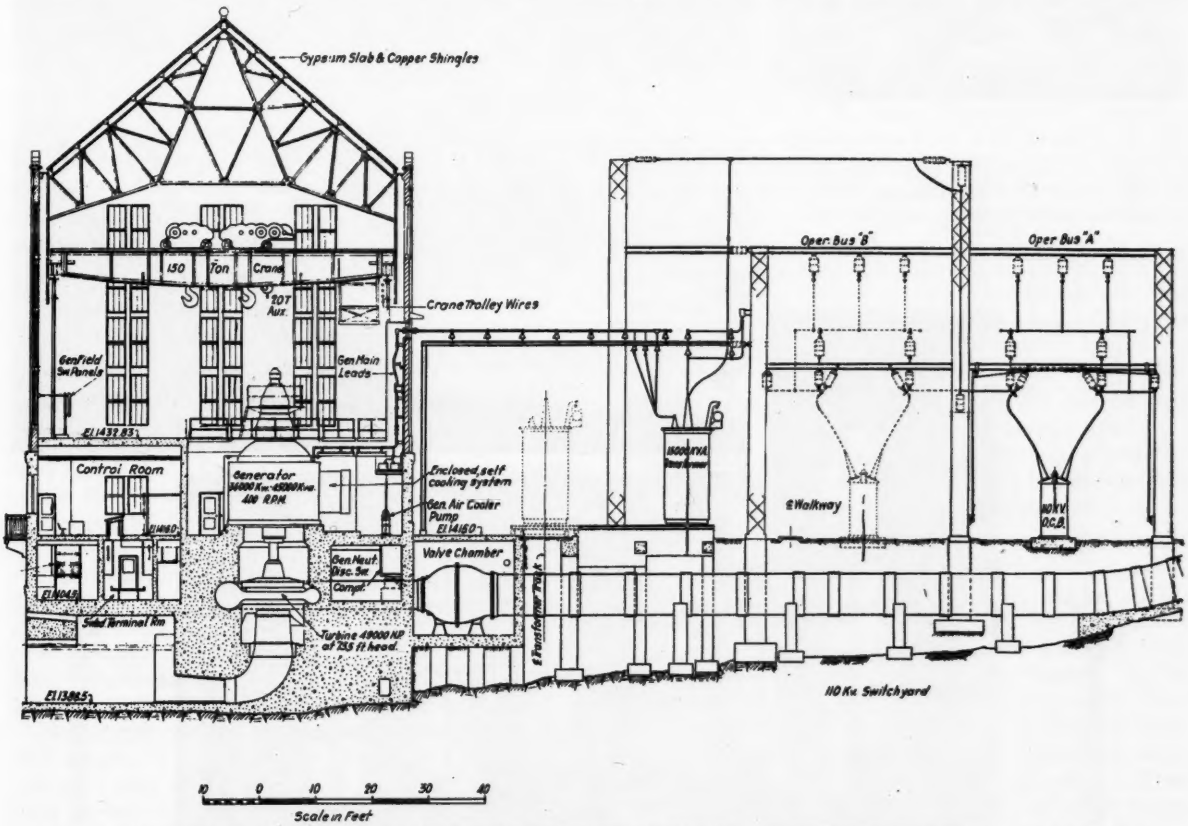


FIG. 1. CROSS SECTION THROUGH WATERVILLE HYDROELECTRIC PLANT SHOWING GENERAL ARRANGEMENT

over 6 mi. through solid rock from an intake near the dam to the power house. The power house is designed to house three 36,000-kw. generating units to give a total capacity of 108,000 kw. at 0.8 p.f. The installation of two of these units has been practically completed and that of the third is underway. Power is transmitted from the plant at 110,000 v., the transmission lines connecting with other systems at Greenville, S. C., Knoxville, Tenn., and Kingsport, Tenn., and with the Carolina Power & Light Co.'s system serving Asheville, N. C., and the surrounding district.

The territory served by the Carolina Power & Light Co. is made up of two separate divisions; the larger or eastern portion is located in eastern North and South Carolina and extends from the North Carolina-Virginia 24,000 kw., both of which are located on the Yadkin River, and the Cape Fear Steam Electric Station, 30,000 kw., which is located near Moncure, N. C.

The smaller or western portion centers around Asheville, N. C., but inter-connection of both divisions of the system with the Duke Power Co. on the south and the Appalachian Electric Power Co. on the north, makes possible the exchange of power from Waterville to the eastern division of the system.

The Waterville power house stands at the junction of Pigeon River and Big Creek near the Waterville, N. C. station of the Tennessee and North Carolina Railroad, approximately 18 mi. southeast of Newport, Tenn., and 35 mi. northwest of Asheville, N. C. The dam is on Pigeon River, approximately 12 mi. upstream from the

Waterville

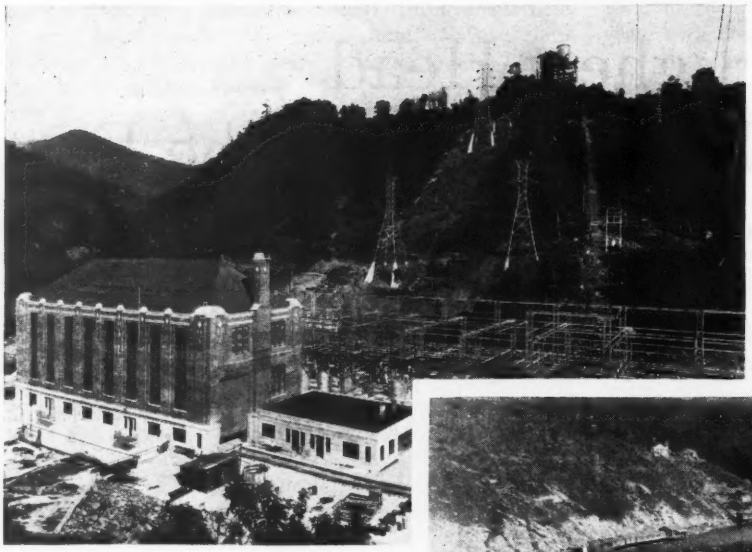


FIG. 2. WATERVILLE PLANT, SHOWING SWITCHYARD AND JOHNSON DIFFERENTIAL SURGE TANK AT TOP OF HILL

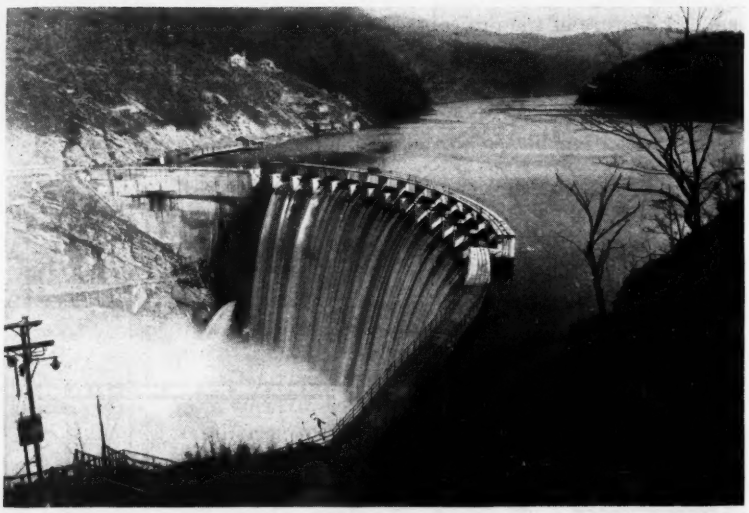


FIG. 3. WATER GOING OVER THE DAM THROUGH THE GATES WITH RESERVOIR FULL

FIG. 4. INTERIOR VIEW SHOWING ONE OF THE THREE 36,000-KW. GENERATING UNITS INSTALLED

power house, accessible by private logging railroad from Hartford, Tenn., on the Tennessee and North Carolina Railroad.

Storage area of the reservoir at El. 2258 (reservoir full) is 340 acres. Capacity down to El. 2175 (maximum drawdown) is 20,500 acre ft.

Variable Radius Concrete Arch Dam

Concrete arch dam, Fig. 3, is about 900 ft. long on the arc at the top; maximum height to crest 180 ft.; top thickness of spillway 22 ft.; top thickness below spillway 16 ft.; bottom thickness 40½ ft. The dam is of the variable radius type, the radius of the upstream face of the arches decreasing from 245 ft. at the top to 220 ft. at the bottom. The downstream face is approximately vertical at the crown; the angle between the ends of the arches varies from 126 deg. at top to 100 deg. at bottom. There are 124,000 cu. yd. of concrete in the dam.

At the crest of the arch dam, the spillway is formed by an ogee section overhanging upstream and downstream faces of the dam 3 ft. It is equipped with 14 steel tainter gates each 24 ft. long by 10 ft. high, operated by three movable, motor-operated drum type hoists, one provided with gas engine auxiliary. Maximum discharge capacity of the spillway is 60,000 sec-ft. Piers between gates are designed to carry a future logging railroad across the dam.

Water Over Dam Falls on Apron

Water discharging from the gates falls free of the dam 11 ft. below the crest of the spillway and strikes the apron approximately 180 ft. below. The apron consists of a concrete mat averaging 5 ft. thick, placed on solid rock in bed of river and extending from the downstream face of the dam 70 ft. The apron is constructed in sections 56 ft. wide, without reinforcing except in one section.

Permanent bypass for the dam is 5 ft. diameter with concrete screens and steel flap gate at the entrance. Discharge from this bypass is controlled by a Johnson free discharge regulator on the downstream face of the dam. Sluiceway, located low enough to unwater the flow line, is lined with extra heavy cast-iron pipe.

Reinforced concrete intake structure is 120 ft. high with structural steel screen guides; it supports the intake gate hoist and a permanent steel derrick for handling screens. Compressed air equipment is provided for cleaning screens. Discharge into the tunnel flow line is controlled by a 90-t. steel gate with fixed rollers that closes an opening 14 ft. 8½ in. by 12 ft. 6 in. This structural steel riveted and welded gate, filled with pig iron and concrete, is lifted by an electrically operated, twin-screw stem hoist of 450 t. capacity. It closes by its own weight.

Flow Line and Surge Tank

Flow line from the intake consists of a tunnel 32, 715 ft. long, horseshoe shaped and of 158 sq. ft. net area. Concrete lining of the tunnel averages 2.3 yd. per ft., equals 15 in. thick. Grades are 2.85 ft., 2.0 ft. and 15.0 ft. per 1000 ft. It has three adits, two at Mount Sterling Creek and one at Gap Shaft. Velocity in the tunnel at full load is 11.3 ft. per sec. The flow-line where it crosses Mount Sterling Creek is a steel pipe 14 ft. in

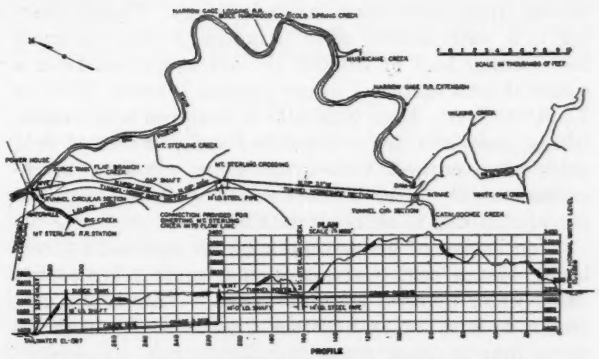


FIG. 5. PLAN AND PROFILE OF WATERVILLE DEVELOPMENT

diameter. For future connection and diversion of this creek into the tunnel, the pipe carries a 24-in. flange.

Surge tank is steel and of the Johnson differential type, supported directly on concrete foundation; height 195 ft. diameter 42 ft., riser in tank 10 ft. diameter; overflow pipe varying from 8 ft. 3 in. diameter at top to 4 ft. 6 in. diameter at bottom. This tank is designed to handle surges for full capacity of the station, 108,000 kw. on or off in 4 sec. No protection is provided against freezing.

The horseshoe tunnel is followed by 200 ft. of 14-ft. diameter circular section leading into the concrete wye 50 ft. long and located 600 ft. from portals. From the wye, three tunnels extend to portals directly behind the power plant.

Three penstocks, one for each unit, of riveted steel plate, 7 ft. in diameter, run 605 ft. from the wye to the tunnel portal and butterfly valve. From the butterfly valve to the Johnson valve at the power house, they continue 175 ft. of riveted steel 7 ft. in diameter.

Control of Penstocks

Two penstock valves control each penstock. At the tunnel portal is a 9-ft. inlet by 7-ft. outlet diameter butterfly, operated by water from the penstock with compressed air provided for emergency closing. At the power house is a 7-ft. inlet by 5-ft. outlet diameter Johnson valve provided with electric motor and Pelton water wheel for quick opening, remotely controlled from switchboard and from pedestal near generator. These valves are designed for maximum head, including surge, of 1280.5 ft.

Turbines and Generators

Main hydraulic turbines consist of three S. Morgan Smith Co. vertical reaction units rated at 49,000 hp. at 755 ft. head, 400 r.p.m. Their cast-steel scroll cases have 5-ft. diameter inlets. They have bronze one-piece runners on the tapering ends of the shafts. Shaft is in one piece for each unit, 19 in. to 21½ in. diameter, 31 ft. 9 in. long; one guide bearing is oil lubricated. S. Morgan Smith Co. governors, oil pressure actuated, are designed to make full stroke in four seconds. No pressure regulator is used.

These turbines drive three Westinghouse Electric & Manufacturing Co. generators, each rated at 36,000 kw., 45,000 kv-a., 0.8 power factor, 3 phase, 60 cycle, 13,800 v., 400 r.p.m. Generators are of the conventional type

having upper and lower guide bearings. Thrust bearing is a water-cooled, 48-in. Kingsbury type, designed for rotating load of 510,000 lb. and supported from a spider-shaped cast-steel upper bearing bracket; WR^2 = 3,850,000 lb-ft². Each generator is equipped with brakes, lifting jacks and fire extinguished coils. Faces of field poles are equipped with amortisseur windings to increase stability after interconnected systems are pulled out of step due to short circuits.

Ventilation of generators is by an enclosed recirculating system with Griscom-Russell surface air coolers using water pumped from the tailrace. Air enters generators at both top and bottom, discharging through the sides into a steel duct containing the air coolers, mounted vertically in two sections and located at one side of the generator. Exciters are direct connected 185-kw., 250-v., shunt-wound, quick-response type, each being separately excited by 10-kw., 250-v. pilot exciter. One spare motor-driven exciter is provided of capacity sufficient for one unit, 200-kw., 250-v., shunt-wound, quick-response type separately excited by a 5-kw., 250-v. pilot exciter.

Main transformers are 10 General Electric 15,000 kv-a., water-cooled, single-phase units, 60 cycle, 13,200 v. delta-66,400/115,000 Y v. These are arranged in three banks of 45,000 kv-a. each with one spare, each bank being connected directly to generator leads and switched integral with it. The switchboard, a General Electric benchboard with vertical instrument and relay panels, is located in a soundproof control room. I. P. Morris automatic frequency and load control switchboard is provided.

Auxiliary power supply comes from a house service unit consisting of one S. Morgan Smith Co. 850-hp. at 734.5 ft. head, horizontal-shaft, impulse turbine direct connected to a Westinghouse, 600-kw., 750-kv-a., 0.8-power factor, 3-phase, 60-cycle, 575-v., 720-r.p.m. generator with direct-connected, 14-kw., 125-v. exciter and from four General Electric Co. 750-kv-a., self-cooled transformers, each 3 phase, 60 cycle, 13,800 v., delta to 575 v. delta, one transformer connected to the leads of each generator and one spare. One switchboard for auxiliaries is equipped with solenoid-operated air circuit breakers installed in a separate room.

Present Status of District Heating

EXTENT, CONDITIONS, PRESSURES, CHARGES AND DETAILS OF SYSTEMS.[1] BY J. H. WALKER[2] AND A. R. MUMFORD[3]

BECAUSE, IN CANADA and the northern United States, winters are comparatively severe and, from national habit, people demand relatively high indoor temperature, quantities of heat used are large. Nearly all buildings are equipped with a central heating system for steam, hot water or warm air so that, except for the warm air, heat can be readily supplied from a district heating system with little change in equipment.

Starting with the New York Steam Co.'s system in 1881, district heating developed to utilize exhaust steam from noncondensing central stations, with the exhaust considered as a byproduct and prices made accordingly. As plants changed to condensing, many were forced to use live steam for their district heating, which the rates made unprofitable until prices could be considerably increased. District heating is a desirable auxiliary to the central station, as it enables the customer to purchase all his service from outside sources, thus aiding the sale of electrical energy.

PRESENT STATUS AND FIELDS FOR DISTRICT HEATING

In case of a new building, district heating, by eliminating some investment and setting free valuable space for rental or use, can compete with the individual plant. Also the public is coming to appreciate the luxury value of outside heating service and is willing to pay somewhat higher than the bare cost of furnishing the heat. Incidentally, there is a civic value in elimination of smoke and of traffic obstruction due to handling of fuel and ashes for individual plants.

For district heating plants, thermal efficiency is from 75 to 85 per cent. Distribution efficiency is 80 to 90 per cent; utilization efficiency, 90 to 95 per cent where condensation is wasted, as is usual. For average values of 80 per cent for boiler plant, 85 per cent for distribution and 93 per cent for utilization, overall efficiency becomes 63 per cent, which is greater than the 50 per cent usual in a small building or the 60 per cent of a large building. This means an appreciable saving in fuel consumption.

Comparing the cost per 1000 B.t.u. to the consumer by three possible methods of outside heat supply:

	Selling Price	B.t.u. for one cent	Cost Ratio
Steam	$0.97 per 1000 lb.	11,400	1.00
Gas	$1.15 per 1000 cu. ft.	4,780	2.38
Electricity	$0.05 per kw-hr.	680	16.76

Steam and electricity can be utilized direct with little loss, while gas must be burned in a boiler or furnace at lower efficiency.

Charge for heating should be based on the heat used, with allowance for large use and high load factor, since cost of furnishing service depends on investment and labor required to be ready to meet maximum demand as well as on actual amount of steam used. A typical schedule of charges is as follows; for coal at $3.80 per ton:

	Charge per 100 lb.
For first 50,000 lb. per mo.	$1.90
For next 100,000 lb. per mo.	1.35
For next 300,000 lb. per mo.	1.10
For next 550,000 lb. per mo.	0.90
For next 1,000,000 lb. per mo.	0.85
For next 2,000,000 lb. per mo.	0.80
For excess of 4,000,000 lb. per mo.	0.75

[1] From a paper before the World Power Conference, Berlin, June, 1930.
[2] Superintendent Central Heating, Detroit Edison Co.
[3] Engineer, New York Steam Corp.

Charge is often subject to adjustment with changing price of coal, the increase being one cent per 1000 lb. of steam for each 14 cents increase in coal price and vice versa. In some cases, charge is based partly on maximum rate of use of steam and partly on total steam used, thus giving high load factor an advantage.

Congested and Residential Districts

Three fields are recognized: Congested districts of business and apartment buildings; individual residences; grouped industries. The first is the most important as offering maximum load with minimum investment. For stores and office buildings, service can be greatly reduced nights and Sundays but apartments and hotels require longer service and the latter need high-pressure steam for cooking and laundries.

High cost of installation and small amount of steam needed make the cost of district heating high for individual residential districts and it is usually unprofitable to attempt such service.

Service to grouped industries is of comparatively recent growth but gives promise of future development of a market, where large quantities of steam are required for process work.

Extent of Industry

Omitting hot-water systems, which are gradually disappearing, 26 companies report invested capital of $80,000,000; revenue for 1928 of $17,000,000; 18,900,000,000 lb. of steam sold to 9322 consumers. Average growth of large and small company business has been some 11 per cent a year. During 1929, eight of the larger companies invested $9,361,000 in extensions and expect to add $10,200,000 more during 1930.

Pressures Used

Systems carrying 50 lb. gage or less are classified as low-pressure; those having 100 to 200 lb. as high-pressure; a third class has both high and low-pressure pipes laid in parallel for serving different requirements. Pressure used depends on customers needs, space available below the streets and the policy in supplying service. For laundries, pumps and small power apparatus, high-pressure is necessary. In some cases, as in the Chicago block system, boiler plants in basements of buildings are interconnected and used to supply a number of adjoining buildings.

New York Steam Corporation supplies a downtown and an uptown district, a total of 2245 customers, from five boiler plants through 191,266 ft. of pipe ranging from 8 in. to 24 in. and at pressures of 100 to 150 lb.

Pipe is of extra-heavy steel with welded flanges and corrugated copper expansion joints, laid in concrete and tile conduit for upper levels and in water-tight cast-iron housings at lower levels. Two inches of insulation, a layer of rubberoid roofing and mineral wool to fill the remaining space between pipe and conduit are used. Condensation is removed by drain stations at low points while valves and expansion joints are enclosed in vaults.

Detroit serves some 2000 customers at 5 to 30 lb. pressure for building and water heating and for cooking. In three of the four boiler plants, electricity is generated more than needed for the boiler auxiliaries.

In Rochester, N. Y., service to industrial plants from electric generating stations, has been developed, steam being bled from the turbines and furnished at 5 to 140 lb. Conditions permit of laying pipe in split tile conduit only two or three feet underground.

Boiler Plants

Because load factor is low in many instances, economizers and air preheaters have not been considered economical. Since plants are usually in congested districts, economy of ground area is necessary and, as it is usually uneconomical to return condensate to the plant, elaborate feedwater treatment is essential. At Kips Bay plant, New York, however, where four boilers, 17,000 sq. ft. heating surface each, are installed for pulverized fuel burning, two economizers are used for each boiler, 5000 sq. ft. each, followed by plate-type air preheaters, 30,000 sq. ft. each. Feedwater is chemically treated in the boilers.

At Detroit, stokers were used because of the difficulty of removing fly ash from the flue gases. Forced and induced draft is provided but no air preheaters. Also refractory furnace walls were installed as giving least total expense.

Rochester, furnishing both electricity and steam, uses economizers and superheaters.

Conditions must determine practice in any case but, in some instances, engineers have felt that supply of steam direct from the boilers was better economy, spite of the gain in thermal efficiency by generating electricity from steam afterward used for heating. Use of pressures of 400 lb. and over, however, renders byproduct generation more attractive.

Distribution

Two methods are used: The trunk system with branches and with pipe size decreasing in proportion to steam demand; and the network, fed at various points by mains. The latter is more flexible as regulation of pressure at all points of the system can be governed according to steam flow.

High steam velocities are feasible, up to 50,000 ft. a min. being common and 75,000 ft. a min. having been attained. These velocities and large drop in pressure make small pipe possible with reduction in system investment.

Heat loss is of minor importance, being 10 to 20 per cent for condensation and steam leaks, or about 50 to 75 B.t.u. per sq. ft. of pipe surface per hour for dry soil and good insulation.

To provide for expansion, slip joints are widely used. They care for several inches come and go but must be located so that they are accessible for renewing packing. Flexible copper diaphragms will care for 2¾-in. movement each and are located at 100 to 120 ft. apart. Corrugated copper expansion joints for pressures of 50 to 150 lb. will take care of ½-in. movement per corrugation. The copper joints need not be accessible and require no attention.

Service to Customers

As most complaints are due to bad conditions in the customers' installation or to bad management, it is found best to assist in arranging a suitable heating system and in operating it economically. This includes inspection of equipment and recommendation for needed changes. Special apparatus to provide for district serv-

ice includes a pressure-reducing valve to maintain desired pressure in the customers system, a trap to drain condensation without leakage of steam, sometimes an economizer to utilize heat of the condensate in heating water and a meter for steam used.

Consumption of heat can be reduced by shutting off heat when not required and by regulating heat supply according to outside temperature, so that overheating will be avoided and windows not be opened. Heat in condensate is about 10 per cent of that in the steam and may be reclaimed by a heat exchanger for partially heating wash room supply.

Upkeep of equipment is also important and is provided for by regular free inspection.

Steam requirements for various classes of buildings, covering heating, hot water and cooking are as follows, the average temperature for the heating season in Detroit being 36 deg. F. and in New York 43 deg. F. Larger values in some instances are for less careful operation of heating system.

Type Building	Lb. Steam per Yr. per Cu. Ft. Space	
	Detroit	New York
Office Building	5 to 8	4.3
Banks	7.9	..
Apartments	11.0	6.9
Hotels	9 to 15	9.9
Large Stores	4.7	2.7
Small Stores	6.1	..
Theaters	5.5 to 7.5	2.9
Garages	3 to 5	1.4

Metering of condensate is desirable where possible but requires that all condensate be returned to one point without leakage. When this is impossible, some form of steam flow meter is necessary, usually of displacement or Venturi type. The flow meter is usually used on high-pressure systems where steam is utilized for power and process work.

Costs

Fuel and capital costs are the largest items, others being much less. The percentages of total cost are: Fuel 30 per cent; other steam generation cost, 15 per cent; distribution, 5 per cent; customer service, 2 per cent; selling, 1 per cent; general and taxes, 7 per cent; boiler plant capital, 25 per cent; distribution system capital, 15 per cent.

Investment cost varies with conditions but will run $4 to $5 per dollar of annual income.

Financial success depends on investment per pound of steam output, density of load, which averages for the country 16,000 lb. of steam sold a year per foot of distribution pipe with maximum of 40,000 lb., selling price per 1000 lb. which runs from 60 cents to slightly over $1, the higher prices being necessary in larger cities.

For business districts and grouped industries, there is increasing demand for district heat supply on a profitable basis and future expansion seems assured. Supply to individual dwellings is not as profitable and is of doubtful success since other automatic methods of heating are now available.

Heat Storage for Four Hundred Million B. t. u.

THE ELECTRICITY WORKS of Hamburg has, as a part of the extension program of its district heating system, installed a vertical heat storage having a volume of 95,000 cu. ft. and a storage capacity of 400,000,000 B.t.u. The heat is stored in water which is heated at the Post Street plant and pumped to the accumulator erected in the center of the heating district, a distance of nearly 3000 ft. When operating the accumulator over a discharge period of 5 hr., it displaces the entire boiler output of the steam plant of 24,000 sq. ft. heating surface.

Primarily the purpose of installing the accumulator was to effect a balance between the various loads of the power and heating operations of the Electricity Works. The heating load is greatest in the early morning hours and drops during the progress of the day, so that the volume of exhaust steam from the power plant which cannot be used immediately in the heating system, increases during the progress of the day. This surplus exhaust steam is absorbed by the accumulator and then discharged from it during the early morning hours into the heating system.

As a result of the installation of the heat storage, the generation of electricity becomes independent of the contemporary heating load and the back-pressure turbines are therefore utilized to better advantage. The greatest advantage of this method of operation is that it can be utilized where peak demand for current and for head do not occur simultaneously. According to the VDI-Nachrichten, it is planned to extend the Hamburg district heating plant by installing a generating unit to operate at about 1400 lb. pressure per square inch and in connection with a 20,000-kw. back-pressure turbine. This will make it possible to store waste heat of about 33,000 kw-hr. in the heat storage.

Clearance of a bearing can easily be determined by means of leads. This method is of use in fitting bearings as well as determining the wear that has taken place after a certain period of operation.

The method is simple; soft lead wire of sixteen or eighteen B.W.G. is used. After removing the cap these pieces of lead wire are laid along the shaft or journal at the point where the clearance is desired. The wire can be placed parallel, but is more commonly placed at right angle to the axis, one at each end and one or more in between, depending upon the length of the bearing.

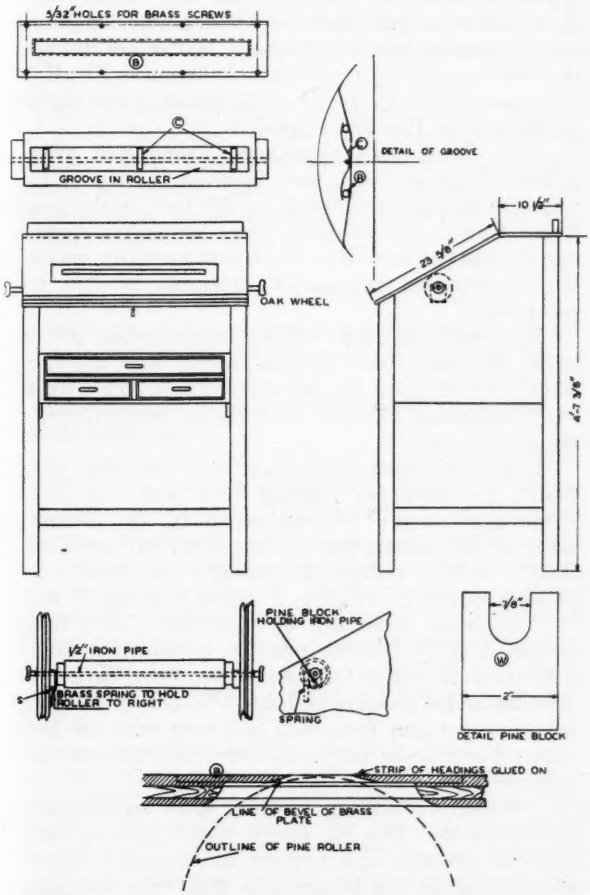
The cap is then set down hard, the nuts drawn up tight, and the wire is pressed out to a thickness equal to the clearance. The leads should be numbered and if they are kept, can be compared with later leads to show the wear that has taken place. The actual clearance can be measured with a micrometer.

Cylinder clearances of engines and compressor can be obtained in the same way. A piece of soft lead wire should be rather tightly wound in a coil to give the necessary thickness. This can be inserted in the cylinder either through a port or drain and held in place while the engine is turned over. The thickness of the lead gives the clearance between the piston and cylinder head.

Roller-Log Desk Assures Clean Record Sheet

CONVENIENT DEVICE WITH SMALL SPACE REQUIREMENT WHICH PREVENTS THE SOILING OR MUTILATION OF LOG SHEETS AND ASSISTS IN THE PROPER RECORDING OF DATA

IN MANY PLANTS, the log sheet is quite a large affair and lies flat on a table or desk, occupying much room. In such a case, the attempt is made to keep the sheet clean and free from hand marks by the use of large blotters or cardboard. Even with this precaution, the sheet becomes soiled and mutilated.



CONSTRUCTION OF OPERATOR'S DESK TO ACCOMMODATE ROLL-TYPE LOG SHEET

DRUM CARRIES LOG SHEET UNDER DESK TOP

To avoid these objectionable features, also to facilitate recording data on the proper line, the use of a protected wooden drum for carrying the data sheet as illustrated was initiated by the Northern States Power Co. and operator's desks of this design are used in the various stations of this company. The application is, however, so simple that the device may be used readily on any desk whether flat or sloping and whether the operator stands or sits while recording data. Although only one drum is shown in the illustration, sometimes, where data is collected at one time on two data sheets, two drums are used.

As indicated, the drum turns in wooden blocks, W, located at the end of the desk underneath the hinged desk top, its axis being a piece of ½-in. iron pipe. The log sheet is wrapped around the drum and fastened by means of spring clamps, C, under which are placed steel rods, R. The length of the drum should be about 2 in. longer than the width of the log sheet. Directly over the roll in the hinged top is inserted a slotted plate of brass, B, the underside of which is beveled so that the surface of the log sheet is not more than $\frac{3}{16}$ in. below the top of the desk.

COLUMN HEADINGS DUPLICATED FOR CONVENIENCE

Since the column headings on the sheet are invisible with this arrangement, duplicate column heads, H, are secured to the brass plate just above the slot and protected with a strip of transparent celluloid or varnished with colorless varnish. In some cases, a strip of glass has been sunk in the brass plate and the duplicate column heads placed below this glass strip. In this manner, a space of about ½ in. of the log sheet alone is exposed while the records of the last two previously recorded lines of the log sheet are visible through the glass.

Carbon copies of the data can be made as readily, if desired, as when the sheet lies flat. Knobs at each side of the desk attached to the pipe axis of the drum permit the drum to be turned to bring any desired part of the log sheets into position for recording data. A ratchet holds the drum rigidly in a given position for any particular line of data. The rolls are large enough in diameter to permit recording a complete 24-hr. run.

Alinement of the drum is secured by means of a spring, S, which keeps the drum in contact with the shoulders at the right of the table.

Over a period of time it is found the general appearance of the finished log is greatly improved—not only that it is never smeared or hand-marked, but that the fixed limits of writing the record through the slot tends to develop in the operators a more uniform and symmetrical style of writing figures and words.

IN VIEW of the importance of the smoke problem in American cities, the United States Bureau of Mines has reprinted the "Proposed Standard Smoke Ordinance" which was prepared by a joint committee composed of representatives of the American Society of Heating and Ventilating Engineers, the Stoker Manufacturers Association, the American Civic Association and the Fuels Division of the American Society of Mechanical Engineers, and which was originally printed in Mechanical Engineering for May, 1924. Copies of this reprint, designated as Information Circular 6262, may be obtained from the United States Bureau of Mines, Washington, D. C.

Noel & Co. Installs Ice Plant No. 2 in Nashville

IN ORDER TO FACILITATE service to all sections of the city, Noel & Co. of Nashville, Tenn., recently put into service a 50-t. motor driven ice plant in E. Nashville.

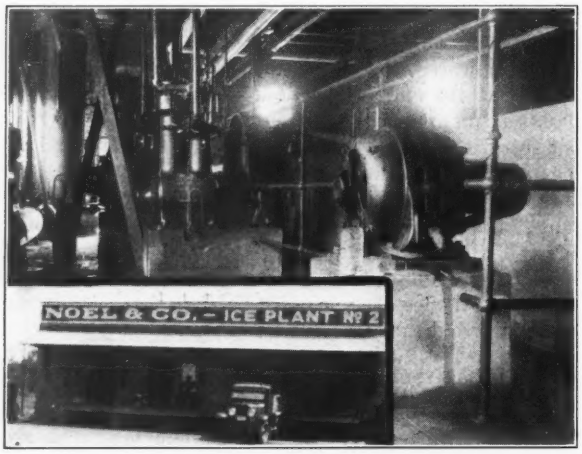


FIG. 1. INTERIOR AND EXTERIOR OF NOEL & CO. PLANT NO. 2

In this plant, the exterior and interior of which is shown in Fig. 1, is installed one Vilter, 10½ by 10½-in., 40-t., and one Vilter 8½ by 7⅛-in., 15-t. machine. The first machine is belted to a 100-hp., 220-v., 3-phase, 60-cycle, 1200-r.p.m. Fairbanks-Morse induction motor with Cutler-Hammer control and the second machine shown in the foreground in Fig. 1 is belted to a 30-hp., 220-v., 3-phase, 60-cycle, 1200-r.p.m. Fairbanks-Morse induction motor with an Allen-Bradley starter.

Capacity of the tank is 552, 300-lb. cakes. They are pulled six cakes at a time by a Euclid two-ton crane, dumped by a Vilter dump rack and stored manually in a small storage vault preparatory to delivery.

The Vilter shell and tube condenser is supplied with cooling water circulated by a Dayton Dowd 400-g.p.m., 60-ft. head centrifugal pump driven by a Fairbanks-Morse, 10-hp. 220-v., 1750-r.p.m. motor with a Cutler-Hammer starter. Additional equipment includes a Connersville blower belted to a Westinghouse 5-hp., 220-v., 60-cycle, 3-phase induction motor, used for supplying air for agitation and a Perfection centrifugal core sucker geared to a Century 1750r.p.m., ½-hp., 220-v., 3-phase, 60-cycle, motor. The Vilter brine agitator is driven by a Howell, 1200-r.p.m., 5-hp., 220-v., 3-phase, 60-cycle induction motor. The Freedman Electric Co. of Nashville installed the electrical equipment.

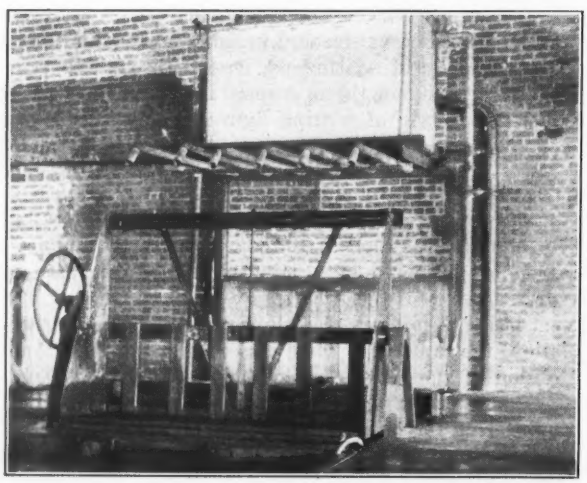


FIG. 2. SIX CAKE DUMP RACK AND CAN FILLER

Hot Ice

PRESSURES SO GREAT that they enable ice to withstand a temperature of 180 deg. and change ordinary substances into new forms of matter are described in a report to the Engineering Foundation by Dr. P. W. Bridgman, Hollis Professor of Mathematics and Natural Philosophy in Harvard University.

Prof. Bridgman's experiments, conducted over a period of several years, have involved the use of compressions equal to 580,000 lb., or 290 tons, to the square inch. Under such pressure, gases become as dense as liquids, and the expansion which heat normally causes in liquids increases, instead of decreases, at low temperatures.

Even the molecules which compose gases, invisible under the most powerful microscope, and the atoms which in turn form the molecules, are driven together, Prof. Bridgman says, by the force he has employed in the experiments.

Important changes in volume were produced, it was found, in substances ranging from water to metals. Under a pressure of 88 tons per sq. in., the volume of many of the metals was decreased several times more than it could be reduced by cooling to the absolute zero of temperature, or 273 deg. C. below freezing of water.

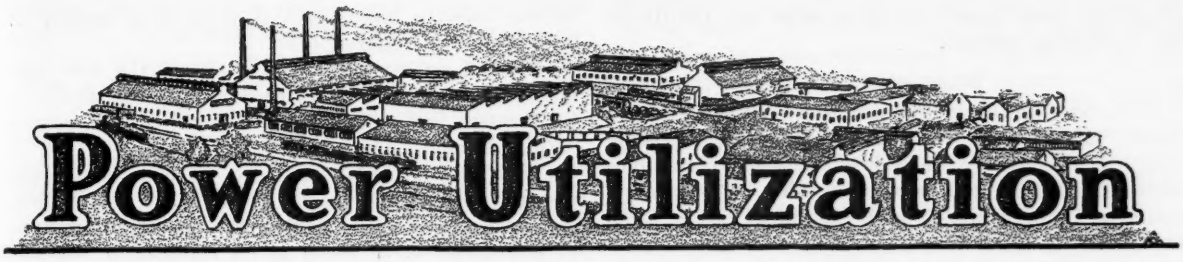
"Electrical resistance of thirty-nine pure metals decreased by hydrostatic pressure by amounts varying with the character of the metal," the report says. "This decrease under pressure of 176,000 lb. per sq. in. ranged from one per cent for cobalt to 73 per cent for potassium. Six or seven metals increased in resistance under pressure.

"Pressure effects on viscosity have been measured for 43 liquids. For all, except water under a limited range of pressure and temperature, viscosity increases under pressure but by amounts that vary enormously from substance to substance.

"The most striking effect produced by high pressure is in the change of melting point of many substances or in the different crystalline forms which are stable under high pressures although not stable under low pressures.

"For instance, the melting point of liquid mercury can be brought up to the temperature of the room by application of 176,000 lb.; ordinary ice becomes unstable at pressures greater than 29,000 lb. per sq. in. and is replaced by other forms, one of which is stable under a pressure of 290,000 lb. at temperatures as high as 180 deg. F., so that we can have the paradoxical substance, 'hot ice'.

"Also there is a new form of phosphorus produced by high pressure which is in appearance like ordinary graphite, is a conductor of electricity and is quite stable in the ordinary atmosphere."



V-Belt Transmission for Power Distribution

PRODUCTION, POWER ECONOMY, PROPORTIONS OF DRIVE, BELT STRUCTURE AND CAPACITY. BY WALTER A. MEYER*

OWING to the increased production trend, the tendency has been to speed up machines wherever possible, too frequently at the expense of the transmission machinery, which, being taxed heavily, soon shows evidence of considerable waste of power as well as rapid wear.

PRODUCTION VS. POWER ECONOMY

Today the power engineer keeps a record of the life of various parts of machinery and bases his future requirements to a great extent on the results obtained in this way just as we buy automobile tires based on speedometer records.

In this modern age of speed, too much emphasis appears to be placed on maximum production obtainable, no consideration being given to maintenance efficiency or economy. Production engineers may claim that proper transmission machinery is too expensive. They would rather permit power losses and excessive maintenance costs than consistently to recommend efficient machinery. The tremendous losses in production volume that result from misapplied and cheap transmission machinery are not covered by such poor practice.

When the management of plants in which this needless waste occurs is aware of the losses resulting therefrom, efficient and economical machinery will be substituted. The responsibility for the recommendation and maintenance of such machinery in the production department will then fall on the power engineer who is in position to direct the most economical procedure, owing to his training and experience. With all the improvements in power transmission machinery contributed by engineers during the past generation, there is a tremendous opportunity for increase in the efficiency from the motor to the machinery with a resultant elimination of power waste and an enormous saving in cost.

One of the outstanding improvements in transmission machinery during the past few years has been the multiple V-belt drive. One drive of this kind commonly known as the Texrope, Fig. 1, was originated by Allis-Chalmers Manufacturing Co. after much pioneering and development work, and is accepted as efficient and economical for transmitting power mechanically.

First demand for a drive having such characteristics as are common to the V-belt drive was created by the textile industry. Practically all textile machinery has been operated through either flat belts or chains. It took this industry but a short time to realize the advantages of the V-belt over existing methods which gave irregular speeds, back lash, high maintenance, bearing troubles particularly in starting, or inadequate production due to interrupted service.

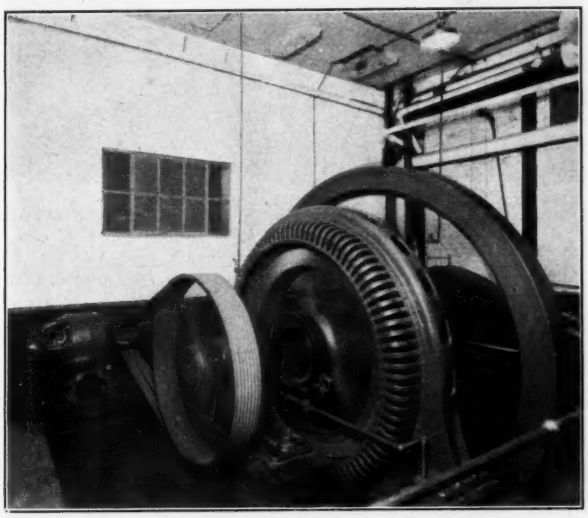


FIG. 1. 16-KW. TEXROPE EXCITER DRIVE

V-BELT DRIVE PROPORTIONS

The majority of V-belt drives fall within speed ratios from 1 to 1 up to 7 to 1, to which the standard has been confined. Occasionally, the ratio must exceed 7 to 1, which is permissible, if the center distance is sufficiently long so that the arc of contact on the small sheave will be 120 deg. or more. This limit of 120 deg. is also standard practice on the regular drive, falling within the speed ratios of 1 to 1 up to 7 to 1. Incidentally the rule that the center distance be approximately equal to the diameter of the large sheave holds true on high ratios as well as on those below 7 to 1.

In a number of applications, the speed ratio is 10 to 1. Since this involves a drive of rather large proportions, many machines do not permit such an extreme ratio. Among the satisfactory applications now in use

*Texrope Division, Allis-Chalmers Mfg. Co.

are triplex stock pumps in paper mills and fan drives for ventilating systems.

Belt Structure

V-belts, being composed of rubber, cotton cords and fabric, impart a smooth starting condition, primarily due to their elasticity, which is of particular importance on spinning frames in a textile mill. In starting a spinning frame equipped with individual motor drive, the motor is thrown across the line, usually with a magnetic type switch operated by a master switch, which, in turn, is actuated by a shipper rod in the hands of the spinner. When the motor is started, a

FIG. 2. VERTICAL SHAFT DRIVE FOR 56-KW. GENERATOR FROM WATER WHEEL

pronounced jerk will cause cylinder heads to be broken, necessitating stoppage of the frame until a new head and shaft can be installed. V-belts with their cushioning effect impart a smooth starting condition and eliminate the jerk.

Texrope drive brought about the first large commercial production of endless V-belts. When first introduced, the endless idea of V-belts was considered by some a handicap and the lack of a suitable belt splice threatened to be a serious obstacle. This proved to be a boon, inasmuch as troublesome splices were done away with and absolutely uniform transmission of power was the result. At first, only a few standard lengths were manufactured but, as the demand increased, sizes were added until today more than 100 different sizes and lengths are carried in stock.

With belt lengths standardized, Fig. 2, the next step was to adopt standards in sheave diameters to facilitate manufacture. Consequently, center distances are more or less predetermined unless the sheaves are manufactured to special diameters in order to meet an exact required center distance between the driver and the driven machine. With as many as 100 different belt lengths, it is seldom necessary to make special sheaves to obtain a satisfactory working condition.

In the early stages, raw edge multiple V-belts were operated in grooved pulleys or sheaves. This raw edge presented disadvantages because of the laminated construction and the lack of an outer coating or covering to protect the cords and fabric in the belt. Also the laminated belt, being without a cover, had a tendency to separate in the plies after being in operation for some time. Foreign matter then had a chance to work its way into the inner portions of the belt, causing deterioration and reduced life.

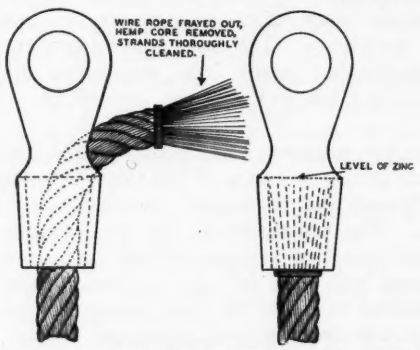
Covered or molded V-belt replaced the raw edge type on account of its greater durability and ability to resist water, dirt and dust which might come in contact with it during operation.

With arc of contact 120 deg. or more and center distance approximately equal to the large sheave diameter, one can roughly calculate the general proportions of a Texrope drive for a given installation, knowing the ratio, horsepower and speed specifications. Since there are only five different cross-sections or widths of belts, each having its own range of horsepower and speed characteristics, the desired width can be selected easily. For example, the smallest cross-section takes care of the range below 2 hp.; the next larger, the range from 2 to 25 hp. and so on. Each cross-section calls for a certain size sheave. For example, the smallest cross-section specifies a minimum sheave diameter of 4 in. This multiplied by the speed ratio of the drive in question gives the diameter of the driven sheave, also incidentally equals the approximate dimension of the center distance which good practice permits. The number of V-belts required for a certain drive depends on the horsepower requirements and the belt velocity.

The arc of contact, or wrap of the belt around the small sheave affects the horsepower capacity of a single belt and, by using a correction factor the normal rating per strand can be definitely determined.

Socketing of Steel Wire Rope Slings

By exercising a little care, the average plant engineer can socket the steel wire slings used by the cranes in his plant, without the least danger of sling failure at



FRAYED END AND COMPLETED JOB IN SOCKETING WIRE ROPE ENDS

the socket. The writer has repeatedly re-socketed slings made of wire rope one inch in diameter and used to lift blocks of stone weighing 35 tons (two slings being used) and has had no failure due to the wire rope pulling out of the socket.

When we find that several of the individual strands of the wire rope have broken, the sockets are removed and placed on new wire rope cut to the proper length. The procedure is as follows: The steel rope is "moused" with a short piece of annealed wire and the ends then passed through the sockets. The wire strands are then frayed out, thoroughly cleaned with gasoline to remove all grease and oil and the hemp core removed from the

portion that will remain in the socket when the job is complete. The brush-like end of the rope is dipped into muriatic acid, which is washed off before drawing the socket up into place.

A few crystals of sal ammoniac are sprinkled into the strands just before the melted zinc is poured into the socket. Babbit, lead or other soft metals must not be used, in fact, zinc is the only satisfactory metal to use for this kind of work. When the zinc is to be poured into place, the lower end of the socket should, of course, be closed by the use of babbit putty and it is well to heat up the socket. As the zinc is poured, it is also well to tap the sides of the socket gently to facilitate the flow of the molten zinc into all crevices between the strands of the wire rope. Allow the metal to cool off, without hastening the process by applying wet rags to the socket. By following this method, a safe and lasting job is assured and the wire rope will break at some other point rather than at the socket.

Cold Spring, Minn. CHAS. A. PETERSON.

Control of Electric Motors

ECONOMIES OF AUTOMATIC METHODS. REMOTE CONTROL. SEQUENCE OPERATION. BY E. G. PETERSON*

USE OF THE electric light has accustomed us to pressing a button to turn electric power on and off. Pressing a button also serves to start and stop the small electric motors on household appliances such as vacuum sweepers and washing machines. On these devices, the snap switch serves as the motor controller by closing and opening the circuit; hence, even for large motors it is natural that the idea of pressing a button to start and stop it be retained.

Current required by large motors, of course, prohibits the use of a pushbutton for handling the motor circuit directly and necessitates interposing a magnet-operated device between the motor and the pushbutton. The National Electric Manufacturers Association defines such a device as a magnetic controller. Whereas small motors can be connected directly to the supply line without serious consequences, large motors usually cannot be started in such a simple manner. The controller engineer is directly concerned with what happens in the motor not only when it is running but also in those few seconds which elapse between the time when the button is pressed and the motor accelerates to its running speed.

FUNCTIONS OF A STARTER

One of the primary functions of any controller is to provide a means for accelerating a motor. Practically all motors require that a reduced voltage be applied to the motor terminal when the circuit is closed, the usual methods being to insert a resistor or a reactor in series with the motor or to provide a low voltage by means of an auto transformer. The automatic starter as contrasted with a manual starter provides a means for automatically increasing the voltage on the motor until the motor is up to speed and running across the line.

Usually, the automatic starter is equipped with either a time limit or a current limit device which eliminates the possibility of damage by an unskilled or negligent operator. The damage that might result is of two kinds, namely, mechanical and electrical. If the voltage on the motor is increased too rapidly, the increased torque will put higher stresses on the shafting, gears and bearings and so may result in stripped gears or broken keys. The automatic starter, by preventing this too rapid increase, reduces maintenance costs on mechanical equipment.

The faster the acceleration the higher the current peaks taken from the line. If electrical power is purchased on a peak demand basis, this will cause higher power bills. The peak currents will cause voltage dips, momentary slowing up of other motors and blinking of lights. By regulating the acceleration, the automatic starter saves power and reduces line disturbance. The heavy currents will cause excessive heating in the motor being started and, if repeated often enough, may cause motor burnouts. It is usually much easier to add overload protection to an automatic starter than to a manual starter. It is therefore almost standard practice with controller manufacturers to incorporate overload relays on automatic starters, which gives increased protection against burnouts during both starting and running.

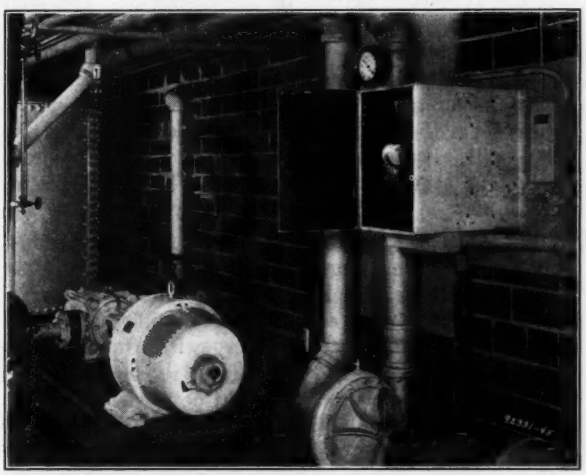


FIG. 1. STORAGE TANK PRESSURE HELD CONSTANT BY PRESSURE REGULATOR AND AUTOMATIC STARTER

REMOTE CONTROL

One of the inherent advantages of an automatic or magnetic starter is that of remote control. A motor-driven pump in the basement of a twenty-story office building may be started and stopped automatically by a float switch in a storage tank on the roof, simply by

*Sales Department, Cutler-Hammer, Inc.

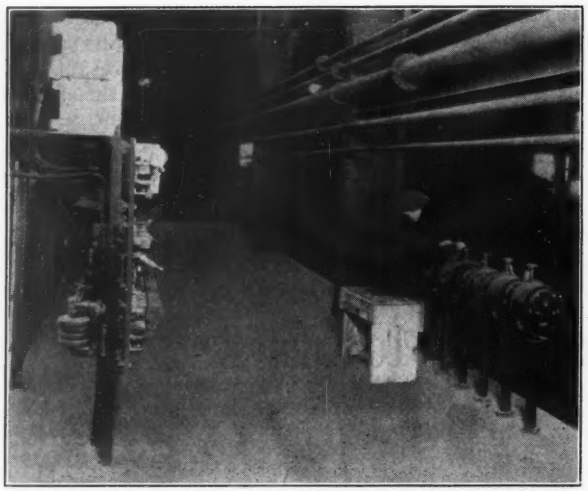


FIG. 2. ELEVATED CONTROL PULPIT IN STEEL MILL WITH 6 MASTER SWITCHES AND CONTROL PANEL

running two small control wires between the float switch and the automatic starter in the basement. The float switch and automatic controller are always on the job. The master float switch is not subject to lapses of attention and will always give uniform control. In other words, the pump will always be started when the water level reaches the same predetermined low level and the pump will always be stopped when the water level reaches the same predetermined high level. The same method may be used to maintain storage tank pressure as in Fig. 1.

When installing large motors, it is possible to make an appreciable saving by using an automatic starter adjacent to the motor and simply carrying the control circuit to the pushbutton master switch to the point from which it is desired to operate the motor. If a manual starter were used, it would be necessary to run the heavy motor leads from the motor to the control

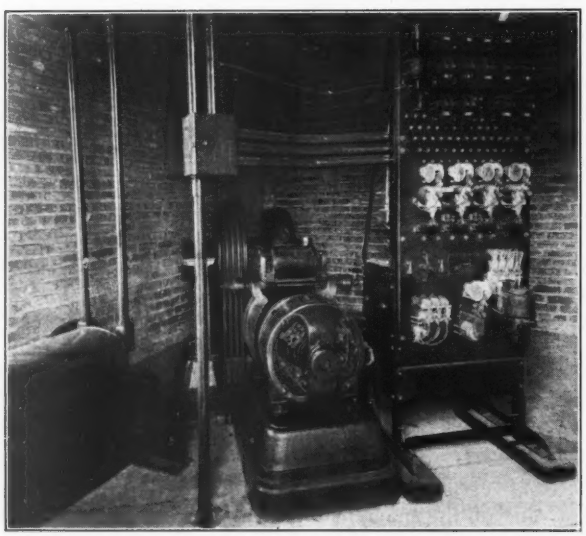


FIG. 3. APARTMENT HOUSE ELEVATOR CONTROL. ENCLOSED SELECTOR, LOWER LEFT, CONTROLS RELAYS AT TOP OF PANEL FOR FLOOR STOPS. LOWER PANEL CONTROLS REVERSE, ACCELERATION AND BRAKING

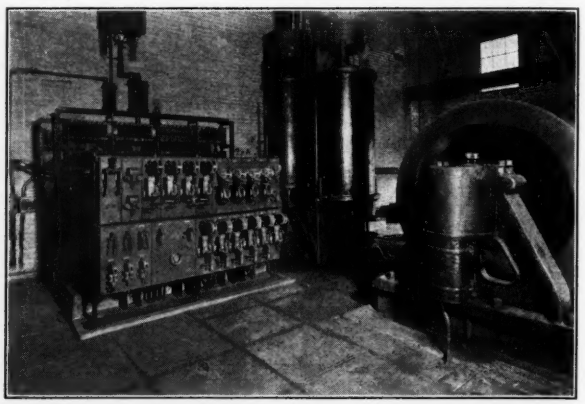


FIG. 4. CONTROL PANEL FOR SKIP HOIST OPERATED BY MASTER SWITCH AT LOADING PITS. ENCLOSED LIMIT SWITCH AT END OF MAIN HOIST SHAFT STARTS DISTRIBUTING MOTOR AS EACH LOAD IS DUMPED

point, involving quite an increased expense. Frequently space is insufficient on a machine for anything but a small master switch. The use of a manual controller in such cases is, of course, impossible. An automatic starter may, however, be mounted on a convenient wall or column or even in the base of the machine and the pushbutton master switch mounted so as to provide control with the operator's finger tip. On some high-speed production machinery such as tire making machines, starting and stopping may be accomplished by foot-operated master switches leaving the operator's hands free for other duties.

Ease of Operation

On some installations, the effort required to operate the manual controllers for large motors becomes an element. Large hoists as used in mines may be operated by a manual type reversing drum controller. The loss incurred due to slowing up in production by fatigue of the operator at the end of the day will be offset by the use of an automatic controller.

By using the automatic method, it is possible to centralize control in a desk or pulpit, Fig. 2. By grouping the master switches in such a manner, the operation of an entire steel mill may be controlled by one or two men, while the space required, expense of installation and effort to operate would prohibit the use of manual controllers under such an arrangement.

It is possible to accomplish results that could not even be attempted with manual controllers. The average elevator installation is an example of this. The pushbutton operated elevator used in the average apartment house, Fig. 3, has to be so simple that even a child can operate it. It has to be almost human in the results it accomplishes. Pressing a button brings a car to the floor. Pressing the proper button in the car will send the elevator to any desired destination. As long as the elevator door is open or the car in operation, it cannot be stopped, misdirected or interfered with in any way by anyone pressing a button at some landing. The elevator car must be slowed down and stopped accurately at the desired landing, must be prevented from over-speeding or over-traveling at the top and bottom. All of these functions and many more are

accomplished by an automatic controller mounted alongside the motor in the elevator penthouse.

Sequence of Starting Up Motors

By using an automatic control, it is possible to synchronize the operation of a group of motors, as in the boiler room control in a modern power house. The modern boiler usually has induced draft fans, forced draft fans, coal-feeding equipment and a boiler feed pump. By means of a master combustion regulator, the fan speeds are varied, the amount of coal fed to the boiler is increased or decreased, depending on the load so as to give the most efficient combustion conditions for any load demand. The motors increase and decrease speed together so that the proper air supply for a given amount of coal is always maintained and the amount of coal is always the right amount, depending on the load on the boiler. For this service, remote control is frequently obtained by using small pilot motors to operate large drum type controllers.

Use of automatic control makes it possible to interlock the operations of several motors in a predetermined sequence or production cycle. The modern blast furnace is a highly developed example of the results that may be obtained by such interlocking, Fig. 4. When the hoist operator on a blast furnace starts a load up the skip hoist, he begins a sequence of operations that is little short of marvelous. The skip hoist bucket is hoisted at high speed, slowed down, stopped and the load dumped within accurate limits by means of an electric controller. As soon as the load is dumped, it is automatically rotated in a revolving hopper at the furnace top and dumped into the small bell. The angle of rotation is based on a predetermined cycle. This revolving hopper is used to give a uniform disposition of the material as it is let into the furnace. After each operation of the skip hoist, the little bell is lowered and the material dumped into the big bell. An automatic electric controller is used which counts the loads and, based on a predetermined selection, after every sixth load or every seventh load as desired, the big bell is lowered and the charge dumped into the furnace. The charging sequence of a certain number of loads of ore, a certain number of loads of coke and a certain number of loads of limestone can be determined in advance and this cycle is always automatically repeated, the only action on the operator's part being that of moving the master controller to the hoist position to start the skip basket up the incline.

Frequently, use of an automatic controller will free the operator for other duties. Instead of concentrating on the operation necessary to start a motor properly as would be required with a manual starter, he can simply press a start button and be free to concentrate on the work at hand. The modern planer motor and other machine tools used in auto manufacturing plants serve to illustrate this point. The automatic planer controller is provided with two knobs by means of which the cutting speed and return speed can be adjusted independently at whatever value is desired. Once a speed has been set, the operator has full control over the planer and his work from a pendant switch having a start and stop button. The pendant switch station also has inching buttons, which give control for setting up of work on the planer. The inch button is sometimes called "hold down" control, since the motor will only run as long as the button is held down.

Lubrication Bettered by Oil Reclamation

Economy Greater, Machine Wear Less by Modern Generous Lubrication and Oil Repurification. By Ralph L. Young*

POSSIBLY IT IS his automobile, 80 per cent of whose repairs we are told are made necessary by improper lubrication, that has brought home to the man in the plant the need for greater thought and care in lubricating the machines entrusted to him. If he has learned a lesson in lubrication from it, everybody stands to benefit.

Today, most plant men are sold on the ultimate economy of the most thorough lubrication that can be provided and, where lubrication failures are common, the trouble may usually be laid at the door of the management which seeks to curtail lubrication expense, by too strictly limiting the amount of lubricants which may be used, by specifying inferior grades of oil, or by failing to provide funds with which a routine lubricating schedule may be carried out.

Even if efficient lubrication were quite costly, the expense would not approach that of repairs, replacements and lost machine time as a result of improper lubrication. But, with modern oil purification methods and machines designed for the easy application of lubricants, efficient lubrication in many cases actually costs less for oil and for labor than the old wasteful and destructive haphazard methods.

*De Laval Separator Co.

Watch the Power Using Machinery

It is but natural that improved lubricating methods had their inception in the power plant where lubricated units are larger and far more costly and oil is used in larger quantities than anywhere else. Here, too, a breakdown caused by lubrication failure may result in a general shut-down of the plant, whereas, in the case of driven machines only the unit itself is ordinarily affected.

It should not be concluded from this, however, that the lubricating systems of the power plant apply only to that particular department of plant operation. If a turbine or other engine can be made to operate more dependably and at lower cost as a result of improving its lubrication, the same must be true of a lathe, a grinder, a pump, an electric motor, a loom or any similar piece of equipment.

Recently, in a plant which found itself burdened with an extraordinarily large upkeep cost for the many cranes it has in service, investigation disclosed that the

FIG. 1. 160 LB. OF DIRT REMOVED IN 10 DAYS FROM THIS ENGINE'S OILING SYSTEM

principal items of expense consisted of bearing and shaft replacements, easily traced to poor lubrication. As it was practically impossible to compel the operators to lubricate the equipment properly, all cranes were fitted with high-pressure lubricating systems and a man was detailed to the work of lubricating them. As a result, not only have maintenance cost and lost time been greatly reduced but the inventory of costly spare parts has dwindled to almost insignificant proportions.

Just keeping oil or grease on a bearing is insufficient to insure against rapid deterioration. The lubricant must first of all be of a grade adapted to the work; it must be present in ample quantity and it must be free from dirt or other foreign matter of an abrasive nature. It is primarily because of this last fact that the pressure or other continuous flow lubricating systems to flush out the bearings are now so universally preferred. Yet, the best of these systems is rendered inoperative as soon as the oil in circulation picks up an appreciable quantity of dirt, so that abrasive materials are continuously carried into the bearing through the oil feed lines.

Some Diesel Plant Instances

At the North White Plains Pumping Station of the New York Water Service Corporation there is installed a 300-hp. Diesel engine, Fig. 1, having approximately 300 gal. of oil in its lubricating system. An ordinary cloth filter was originally provided to strain impurities out of the oil. After two months, it was noted that the oil had become so laden with impurities that its further use was inadvisable. As the cost of replacing the used oil with new would have been approximately 50 per cent of the cost of installing a centrifugal oil purifier, it was decided to install the purifier, and within ten days after its installation this machine had removed 160 lb. of dirt from the lubricating system.

True, a large part of the so-called dirt removed from this Diesel engine was carbon formed as a result of combustion but almost every machine operates under its own peculiar disadvantages as regards lubrication. While a lathe, for example, will put no carbon into its lubricating system, the oil is open to a serious menace in the form of tiny particles of steel.

An instance of this is found in the plant of the Donner Steel Co., at Buffalo, N. Y., which uses four Diesel electric locomotives for interplant haulage and switching service. Fuel oil for these locomotives is delivered from tank cars to storage tanks from which it is transferred to the locomotives as needed. Despite the usual precautions taken to keep the oil clean in storage and during handling, it was found that the characteristic dust of the steel mill was getting into the oil and causing excessive wear on fuel injection nozzles and the pumps through which the oil was handled. Installation of a centrifugal oil purifier to clean the oil before its delivery to the locomotives has corrected this trouble.

In a Newspaper Press Room

Perhaps the last place where anyone would expect to find much attention paid to the problem of securing really economical lubrication is the press room of a daily newspaper. Yet the New York World has found this problem of sufficient importance to warrant special

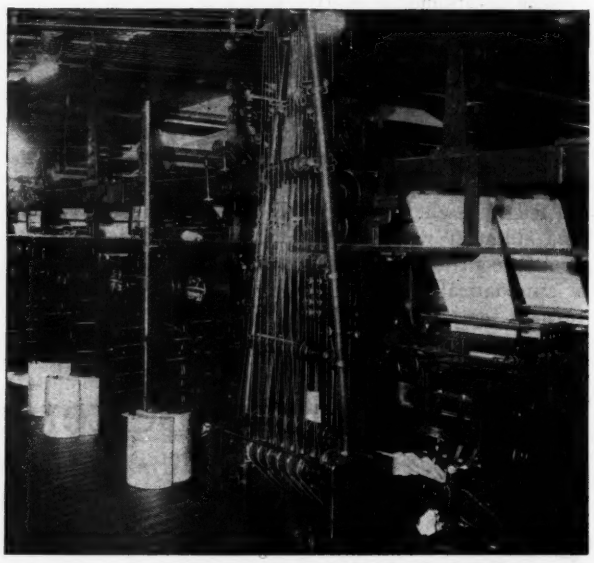


FIG. 2. DUPLEX NEWSPAPER PRESS HAS HUNDREDS OF BEARINGS TO BE LUBRICATED

study and the installation of a comprehensive lubricating and recovery system.

Since a modern newspaper press, Fig. 2, may have as many as 200 bearings, many of them operating at high speeds and under considerable pressure, lubrication becomes a matter of extreme importance. Manual lubrication is out of the question and so, on certain types of presses, small copper oil lines are run to each bearing and a measured quantity of oil is forced through them to the bearings at regular intervals by means of force lubricators geared to the press.

This gives efficient lubrication, but requires a large amount of oil, most of which ordinarily runs off the bearings and is lost. The New York World and other newspapers have constructed oil drain lines at either side of the presses to catch this oil, which is collected in a receptacle and eventually goes to the oil purification room for removal of ink and other impurities, then is returned to the lubricating system.

With such a system, it becomes an economy to increase the feed of oil to the bearings, guarding against excessive wear, and the press can safely be operated at higher speeds, which increases the possible production of each machine. Saving of oil is of considerable importance but is almost inconsequential when compared with the greater dependability of operation.

Ample Lubrication Can Be Inexpensive

Although improvement in lubrication appears to have as its basis the use of more oil, actually nothing of the kind need occur. With the reservoir type of machine a suitable purifier is connected by means of piping so that oil in the reservoir is continuously circulated and purified and can be continued in service almost indefinitely. Where drip lubricators are used, a system can be used for recovering and purifying oil which drips from the bearings.

In plants where large numbers of machines have relatively small oil reservoirs containing perhaps only four or five gallons of oil each, such machines should be piped up to a central oil purification plant, a simple matter, so that a small stream of clean oil can be continuously fed into the oil reservoir of each individual machine, while a like quantity of oil is returned from the bottom of the reservoir to the purification plant. In order to maintain the proper quantity of oil in the reservoir, the oil is taken off through a goose-neck having as its highest point the desired oil level.

Such a system is widely employed in steel mill lubrication, especially for bearings that are ring-oiled from a reservoir. Another instance is found in the production testing rooms of automobile factories, where each test stand is connected by means of piping to a central oil purification system. In some cases, the flow of purified oil amounts to from 30 to 40 gal. an hour for each motor, this rapid flow of oil carrying much abrasive matter out of the new machine, effecting a marked reduction in initial wear and saving much trouble which previously resulted from scoring of bearings.

Another example of oil purification earning a substantial profit is a large manufacturing plant which on many automatic screw machines employs a straight mineral cutting oil to cool and lubricate the work. Lubricating oil, if fed in large quantities, dripped into the cutting oil sump and the mixture was most decidedly a poor one for the particular metals being worked, so that large quantities of mixed cutting oil and lubricating oil were, from time to time, withdrawn from service and discarded.

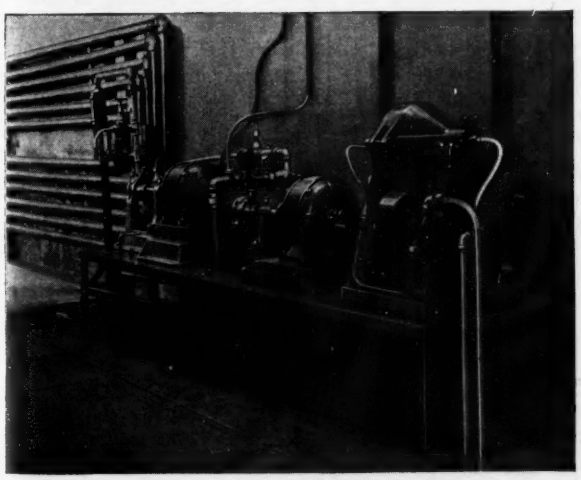


FIG. 3. OIL CLARIFIER, AT THE RIGHT, OPERATES WITH MERELY OCCASIONAL CLEANING. MOTORS AND PUMPS AT LEFT ARE NOT PART OF THE CLARIFYING UNIT

In this case, the plant superintendent found that clean cutting oil was quite capable of efficiently lubricating his machines even though his lubricating oil could not be made to serve as a cutting lubricant. Accordingly he installed an oil purifier to keep the cutting oil clean, thus solving his lubricating problem and, at the same time, materially improving the quality of the cutting oil itself.

Little Attention Needed for Smaller Plants

Oil purification need not be costly as to labor. In a large central station or mill where several thousand gallons of oil must be purified daily, a purification plant sometimes requires the full time services of one man. In hundreds of smaller plants, however, the purification system requires but an hour or so of attendance weekly.

Such a system is found in the plant of Vulcan Rail and Construction Co., Brooklyn, where the lubricating oil for a 240-hp. Diesel engine is continuously purified by means of a centrifugal machine, Fig. 3, which operates for hours at a time without attention. This centrifugal is designed so that power failure, clogging of the bowl by accumulated dirt removed from the oil, or other similar trouble cannot result in loss of oil or in lowering the oil level of the engine; hence the only attention necessary is to start and stop the purifier and occasionally clean from it the dirt removed from the oil.

From every viewpoint, oil purification is economical and entirely practical wherever it is felt that maintenance costs can be cut by better lubrication, or oil bills can be reduced by putting used oil back into service.

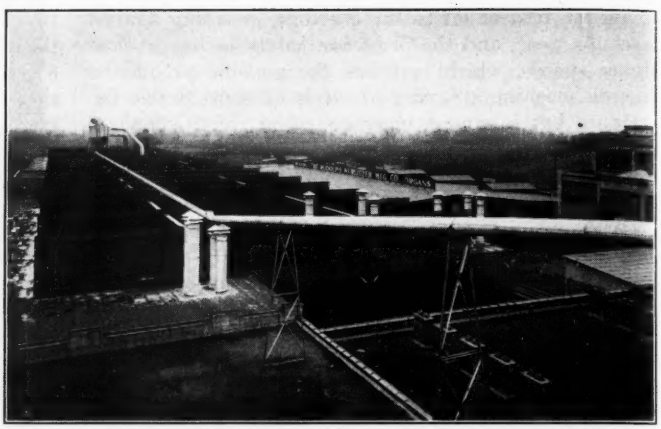
It has been estimated by one well-informed student of world development of electric light and power, says the N.E.L.A., that the production of electricity throughout the world is in excess of an annual rate of 300 billion kilowatt-hours. On this basis the United States is contributing 1 kw-hr. of electrical energy for every 1.4 kw-hr. generated by all the rest of the world combined, or 41 per cent of the total.

Germany ranks second in production, with an output of 34 billion kilowatt-hours; Canada third, with 18 billion; while Great Britain and France are about tied for fourth place, each with an annual production of approximately 16 billion kilowatt-hours.

In commenting upon the electric power industry in Canada, which occupies second place in world production, the Department of Trade & Commerce states that "although the low rates are important factors in increasing the average consumption per capita . . . the large consumption by the pulp and paper industry is the main factor." Practically 8 per cent of the total Canadian production is exported into the United States.

The kilogram calorie, used in Europe, is equal to 3.968 B.t.u.

MODERN WOOD WASTE COLLECTION



By
C. N. Deverall *

IN THE LAYOUT of modern woodworking plants the collection of dust and wood waste has come to be a subject of importance, secondary only to the woodworking machines. Most of us who have been connected with the woodworking industry for any length of time can remember plants in which the waste collecting system consisted of a crew of sweepers who made periodic trips through the plant and tried to keep a jump ahead of the accumulating waste. We can also remember the dust begrimed woodworking machine hand who spent his day in an atmosphere of flying chips and dust, with its attendant menace to safety and health to say nothing of his having to dig his machine out whenever he had occasion to sharpen or reset it.

Modern production methods, modern factory laws and a real desire on the part of the more progressive manufacturer of today to make his plant safer, cleaner and a healthier place in which to work, have practically eliminated plants of this type. Possibly a few of them are left but the woodworking industry has grown to such proportions and so many fine plants have been built within the last few years that the percentage of the old type plant is almost neglible.

For some years, woodworking plants have been equipped with systems more or less effective in the collection of waste from the cutting heads of the machines.

*Chief Engineer, The Rudolph Wurlitzer Mfg. Co., North Tonawanda, N. Y.

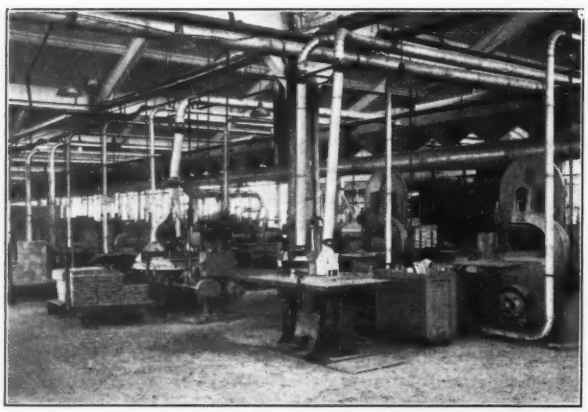


FIG. 1. PLENUM MAIN IS CONNECTED TO VARIOUS MACHINE HEADS

These systems have generally been arranged so that the shavings were conveyed directly to the boiler house and either fed directly into the furnace or to a storage bin from which it could be fed as required. Manufacturers have found that the installation of proper equipment has taken wood waste out of its former classification as a nuisance and a bill of expense, making it a by-product which can be made to pay dividends.

Wood Waste Disposal Needs Flexibility

As the average woodworking plant requires considerable steam for dry kilns, glue heaters and other apparatus, the far seeing manufacturer who utilizes his wood waste for the making of steam has an outlet in his own plant for it and the fact that steam can be used for the generation of power and the exhaust taken off at a pressure sufficiently high for process work and heating allows full utilization of the heat value of the waste.

In most systems, the weak spot has been a lack of flexibility in making changes in plant layout. This was due to the fact that the machines were first laid out and piped up in such a way that the main was gradually increased toward the blower as the various machines were hooked in. This practically eliminated the possibility of changing the position of, or adding machines to the line without radical changes in the piping layout. Under old production methods, this was not a serious handicap, as work was taken from machine to machine without much thought as to waste effort in handling. Modern straight line production, however, demands that each machine be placed in definite relation to other machines. This necessitates the changing of machines or the addition of machines at definite points when the method of producing an article or a change in the design of an article is made.

Large woodworking plants such as the automobile body plants, furniture and radio cabinet plants, in adopting modern progressive production methods have found it absolutely necessary to look for a system more flexible than the Tapered Pipe System just described, which leads up to the case in point.

The Rudolph Wurlitzer Co.,[1] manufacturer of musical instruments, has kept abreast of the times as is evidenced by its modern plants, particularly the plant at

[1]See page 919, Aug. 15, 1930 issue for description of the new boiler plant.

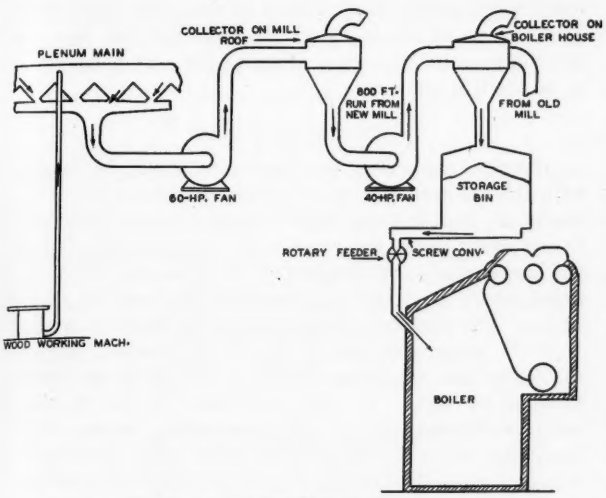


FIG. 2. FLOW OF WASTE FROM MILL TO BOILERS

North Tonawanda, N. Y., which comprises the piano, organ and radio divisions. An increase in the production of radio cabinets necessitated the building of a large addition to the woodworking mill. This building, a modern saw tooth structure of long span construction 600 by 120 ft., presents the last word in modern plant building and equipment. The machines are arranged in definite sequence and a serious effort has been made to provide flexibility in machine layout. As a new boiler plant was planned at the same time, it was possible to design a complete system of waste handling, unhampered by the usual limitations imposed when new equipment is added to old.

Thorough study was made of the handling of all waste from the cutoff saws to the boiler room. Obviously such a plant could use no system which imposed limitations as to the placing of machines and the policy of the firm to maintain a spotlessly clean plant at all costs made necessary the combining of flexibility and efficiency. It was found that several systems were in vogue in which the grouping or regrouping of machines bore little or no relation to the effectiveness of the system and the investigation was narrowed down to these particular systems, the Tapered Pipe system not being considered at all.

Roughly, these systems are divided into two groups, the first of which is a combination of pneumatic and mechanical equipment, the waste being taken from the machine pneumatically and conveyed mechanically to the point of disposal. A large main into which the machines are piped is located, usually in the center of the building, and is provided with a chain conveyor running in the bottom. A blower exhausts the air from this main, drawing the shavings into it, while the chain conveys them to the point of disposal.

Plenum All-Pneumatic System Used

The second system is completely pneumatic, the shavings being handled entirely by air taken in at the cutterheads. After considerable study, this latter system was chosen for the new plant.

Two systems are comprised in the mill in the installation, also a relay system to carry the waste to the boiler room which is located about 800 ft. distant. Two large mains, called by the manufacturer of this system Plenum Mains, are located in the center of the building. These are built with a semi-circular top and a series of hoppers in the bottom, Fig. 1. Into the top of these mains, pipes from the machine heads are run and the series of hoppers are connected into pipes tapered from the ends and gradually enlarging to the center where each is connected to a fan driven by a 60-hp., 725-r.p.m. motor, Figs. 2 and 3. These two mains are placed end to end and so arranged that the opening of a large blast gate makes it possible to run the two as a single unit, while, if only one section of the plant is being operated, the gate can be closed and only one of the fans operated.

Were it not for the fact that the boiler house is located at such a distance, these fans would carry the shavings directly to a collector on top of the boiler house where they would be fed directly to the furnace or to a storage hopper over the furnace. In this particular case, however, as the boiler house is so far away from the mill, a collector is provided on the mill roof into which both of these systems discharge, see headpiece illustration. Waste from this collector is fed to a fan driven by a 40-hp., 1425-r.p.m. motor which blows the waste through a 14-in. pipe to a collector on top of the boiler house. Over the top of each boiler a 2000-cu. ft. storage bin is provided, the waste being fed into these bins from this collector. These bins are so laid out that an auxiliary system will carry shavings from either one to either boiler, so that the full capacity of the two bins can be utilized for storage even though one boiler is being operated.

Feed of Wood Waste to Furnace

At the bottom of these hoppers screw conveyors are provided, which convey the waste to air-tight feeders interposed between the storage bin and the furnaces, Fig. 2. These feeders serve two purposes. They prevent any possibility of a puff back from the boiler to the storage bin and they have a tendency to regulate the feed more evenly than would be the case with the screw conveyor, which has a tendency to bring the shavings along in lumps. The feeders, being constructed somewhat on the principle of a paddle wheel, can take only a given amount of shavings at a time and are run at a speed which insures an even feed. This is important

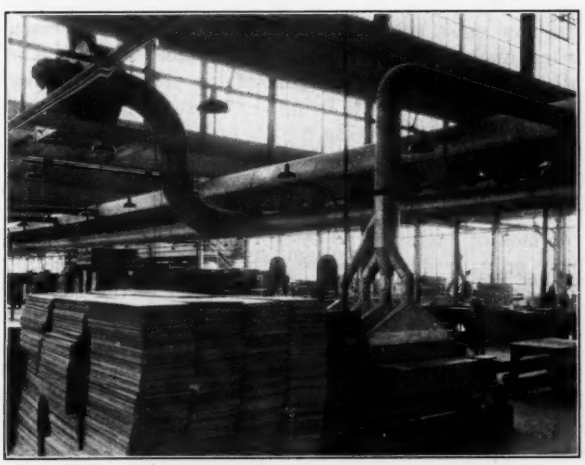


FIG. 3. 60-HP. FAN DRAWS AIR AND WASTE FROM LOWER MAIN AND DISCHARGES TO ROOF COLLECTOR

because the tendency in burning shavings, if they are fed irregularly, is to have a puffy fire which can never be efficient; if, however, the shavings are fed at a steady rate, good operation is possible.

Shavings are fed into the boiler at a point of about 25 ft. up from the floor of the furnace. As this is a pulverized coal job, there are no grates and the feeder is controlled by a special variable-speed device operated by a pressure regulator, which speeds up the feed when the pressure drops and vice-versa. It is found possible to hold the pressure within five pounds continuously. As a complete description of the boiler plant will be found in the August 15 issue, no further description of this part of the equipment will be necessary.

Action of Plenum System

To sum up the operation of the system, reference to the diagram and photographs will leave little need for

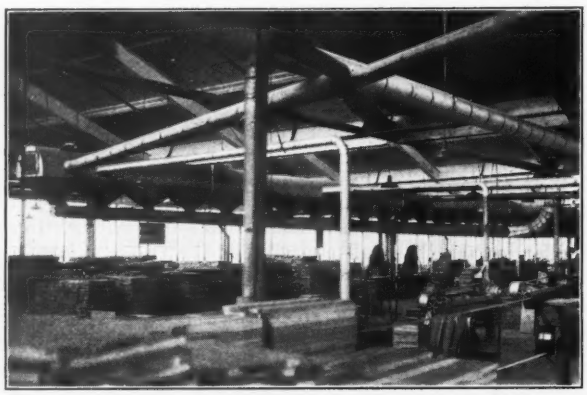


FIG. 4. CONNECTIONS IN SANDER ROOM. ACCESS DOORS IN ENDS OF MAINS

explanation, as the whole operation is simple. In exhausting the air from the lower pipe of the main, the fans will create a partial vacuum in the upper chamber, exhausting it through the ports in the bottom of the hoppers. As the size of these ports or their number is not altered by the addition or change in position of machines, suction would be maintained in the lower pipe, even if the whole top of the upper main were opened up. This is due to the fact that the air going to the fan must come through the hopper ports, which, being unchanged, will maintain this suction constant at all times. The mere changing of the position of a machine will serve only to bring the waste in at a different point, not at all affecting the amount of air handled.

If the system were overloaded to the point where it must fail, only the upper main would be affected and the waste would not be taken from the machines, due to the lack of suction. To correct this, it would be necessary only to subdivide the lower pipe, adding another fan and piping the exhaust of this fan to the collector which feeds into the auxiliary system to the boiler house. In other words, if the waste can get into the upper main, it must get away as it depends only on gravity to get into the lower pipe. As was pointed out before, this lower pipe, being maintained at a constant suction, will deliver the waste to the collector.

In the case of a large machine, such as a double surfacer or a straightoplane running on a heavy cut, too much waste might be delivered at one point to be handled by one of the hoppers. If this were the case, the residue would simply pass along to the next hopper and so on until it got away.

Clogging Is Avoided

Overloading causes no clogging as would be the case with the old type system, in which a machine delivering too much at one point would cause a partial stoppage, thus cutting down the amount of air being handled by the blower and immediately reducing the capacity to the point where it would not move the shavings out of the main. The shavings, however, would keep on coming from the machine as long as any suction was left and, as the main was not being cleared, it would be gradually plugged up tight. Anyone who has ever had to clean out one of these systems will know what I mean. Such stoppages will naturally always occur when production is heavy, with a corresponding heavy loss and much bad feeling all around.

Experiment has shown that as many as six or eight of the hopper ports can be closed up in one continuous row with no apparent effect at the machine head even of machines which are connected into the plugged section. Some of these ports were closed up and observation was made of a large planer running under such conditions. It was found that shavings were simply carried over the plugged section and found their way into the lower pipes at the first open hopper. The Plenum Main is large enough for a man to go through easily, so that inspection is simple. Tests have also been made as to the method of cleaning the main, should it get plugged and it has been found that it is to clean it out with the system running. It is simply a matter of going down through the shavings with a hook, getting the obstruction out and allowing the shavings to get away. When the woodworking machines are not running and feeding shavings into the system, a man can work quite comfortably inside of the main with the fans running. Access door in the end is shown in Fig. 4.

Just a word as to the relay system. This caused a little concern, due to the fact that the boiler house was so far from the mill but no difficulties have been experienced in carrying shavings this far and there is every evidence that a much longer run could be made if necessary. The 800-ft. run seems to present no trouble at all. Even good sized pieces, such as might break off a turning in the automatic lathes, come through.

In describing this system, I do not wish in any way to convey the impression that this is the only practical system or to detract from the merits of other systems which are in successful operation in other plants. Nor do I wish to detract from the merits of the Tapered Pipe system for plants where no changes are likely to be made in the layout of machines. In such a plant, a Tapered Pipe system properly laid out and built is perfectly practical and can be installed for considerably less money than a system such as the one described. Even here, however, the services of a competent engineer are necessary. Too many of these systems have been laid out by tinsmiths, who knew little or nothing of the principles involved in pneumatic conveying. Where changes in the machine layout are constantly being made, however, the buying of a cheaper system is false economy.

A point which is often given too great a part in the selection of dust collecting equipment is power. Some manufacturers of this equipment make a strong point of showing how much less power is needed for their system than for a competitive one. The result is that many users have found that a slight addition to the initial installation will require an addition of power. At the rate that manufacturers buy power, the little extra consumed by an oversized motor is not an important consideration. One shut down in a busy season would probably pay for all the extra power consumed in years and certainly the changing of the system after it is once installed would cost much more than the installation of a larger motor in the first place.

In the case of the installation just described, motors

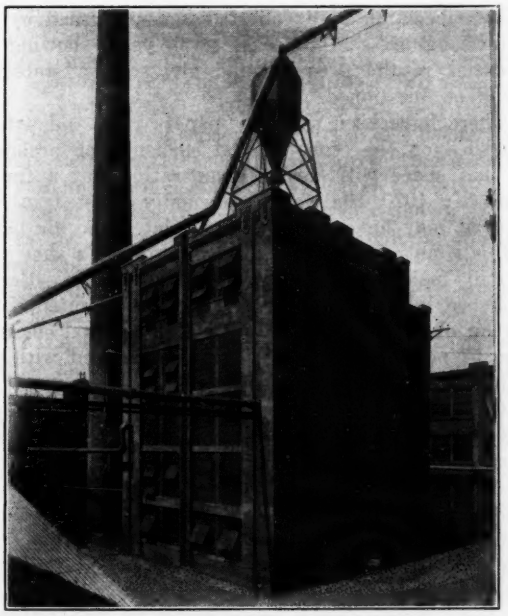


FIG. 5. COLLECTOR ON TOP OF NEW BOILER HOUSE. THE PIPE COMING DOWN AT THE LEFT IS A CONTINUATION OF THE ONE SHOWN IN THE HEADPIECE

were purchased 10 hp. larger than called for by the manufacturer of the equipment, as it has always been the policy of this plant to have machines slightly overpowered. It is found that an oversized motor running under capacity will take practically no more power than a smaller motor running full capacity and the difference in wear and tear on the machine makes it well worth while paying for the additional capacity.

The writer would not care to enter into a controversy with several manufacturers of systems of the Universal Type and so will refrain from commenting on the comparative merits of the various systems. He can say, however, that the system described has operated splendidly over a period of almost a year. Experience with both old and new systems, not forgetting the manual system spoken of in the first of this article, has brought to the writer the realization that waste collection is of so much importance to the operation of a plant and to the welfare of its employes, that all the care and judgment exercised in its selection and installation will be amply repaid. Never forget that while a clean plant is not always an efficient one, a dirty plant never is.

Midwest Power Engineering Conference at Chicago, Feb. 10-13, 1931

TWENTY REPRESENTATIVES of the foremost engineering societies in the power field met recently in Chicago to outline plans and arrangements for the Fifth Midwest Power Engineering Conference. Past meetings of the Conference have been held in Chicago since 1925 and the next meeting promises to be of greater importance than any preceding it.

Work of carrying on the four-day meeting scheduled for Feb. 10—13, 1931, inclusive, at Chicago will be in the hands of the following officers recently elected: President, H. W. Fuller of Byllesby Engineering & Management Corp.; vice-presidents, C. C. Whittier, Chicago; W. M. White, Milwaukee, Wis.; Charles S. Gladden, Detroit, Mich.; Paul Doty, St. Paul, Minn.; John Hunter, St. Louis, Mo.; Prof. A. C. Willard, Urbana, Ill.; secretary, G. E. Pfisterer; treasurer, K. A. Auty. Headquarters have been established at 308 W. Washington St., Chicago, Illinois.

The Conference will be sponsored by the local sections and regional divisions of the following: American Institute of Electrical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, American Society of Refrigerating Engineers, National Safety Council, National Electric Light Association, Western Society of Engineers.

Several committees have already started work for the four-day meeting and a canvass is being made to secure the latest ideas and most modern applications of power and its allied subjects. The rapid progress in this field and in the field of Physics so closely allied, will allow a presentation of subjects of national interest, it is stated. Leading authorities in the heating, refrigerating, mining, electrical and and mechanical fields will be asked for expressions of the progress of power application in these fields, to give a comprehensive survey of generation distribution and utilization in a large way.

The real purpose of the power conference at Chicago is to coördinate the various problems in the power field to give a broader understanding of applications in many different fields of use. The part of power in our daily life and in special work will find expression in the diversified papers contemplated.

IOWA PUBLIC SERVICE CO., Sioux City, Iowa, will expend $250,000 this fall upon transmission lines, power units and installation of lighting systems in LeMars, Iowa, and Jefferson, S. D., according to W. J. Bertke, president of the company. The principal expenditure will be a 20-mi. transmission lines from the Court St. plant, Sioux City, to Moville, carrying 33,000 v., costing $100,000; with $90,000 spent upon new Diesel engine installation at LeMars as an emergency unit there in case of interruption from the Sioux City station.

EXTENSIVE INJURIES seldom become infected, for the reason that the employe is forced to report such cases for immediate treatment. It is the minor injuries which appear insignificant to the employe that are neglected and frequently require surgical attention.

Selecting Stokers for New England Fuel

IN THE JUNE 1 issue, page 620, is an article by R. A. Foresman and D. J. Mosshart entitled "Selecting Stokers for New England Fuel."

There the authors say that stokers which burn Illinois coal at 10,000 B.t.u. per lb. at a combustion rate of 80 lb. per sq. ft., could not be expected to burn New River Coal of 14,000 B.t.u. per lb. at 57 lb. per sq. ft. of stoker area. This seems to be the reverse of what we had always believed and a search through the files of the Prime Movers Committee reports of the N.E.L.A. seems to substantiate our belief. It is generally considered that Midwestern coal with high ash and high sulphur could not be burned as easily as Eastern Bituminous coal and therefore the rate of combustion of the Eastern coal would be higher.

The above point, however, is not of as much importance as their statement that preheated air does not measurably increase capacity or efficiency. In the face of all the operating data collected and published by the engineering press in the past seven years showing the beneficial results of preheated air, such a statement should be questioned.

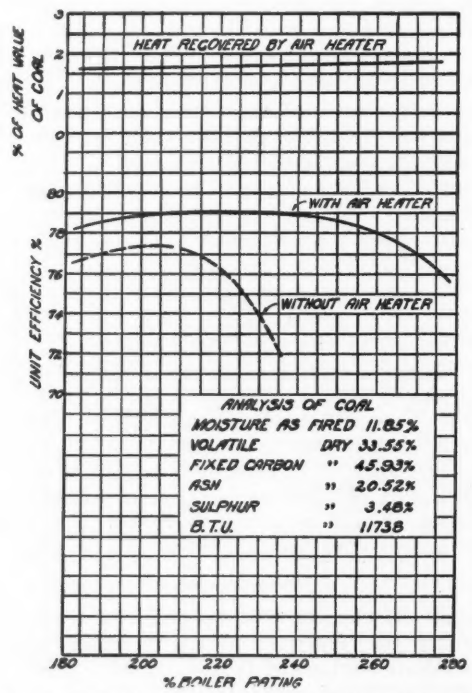


FIG. 1. EFFICIENCY AND CAPACITY INCREASE DUE TO AIR HEATER AT NORTHEAST STATION

There have been so many papers read and articles published on the economy and efficiency of preheated air that space will permit enumerating but a few of them. In 1920, the writer personally assisted in tests on what may have been the first plate type air heater in this country. These tests were run on a shell type oil still, making batch runs of wax distillate. Results published in 1929 as Bulletin 302 of the United States Bureau of Mines show an increase in thermal efficiency from 57 per cent with cold air to 71 per cent with preheated air.

One of the earliest investigations of the use of preheated air in boiler practice is given in the paper "Boiler Test Results with Preheated Air" presented by C. W. E. Clarke before the A.S.M.E., December, 1923. An abstract of his article was published in Power Plant Engineering, Dec. 15 of the same year. It should be known that Westinghouse stokers were used and in summarizing, Mr. Clarke says that during the test, Westinghouse engineers made the following notes:

1. The fuel bed was much more uniform with preheated air and no holes or disturbances of any kind appeared to break up the uniformity of operation.
2. The fuel ignited more readily.
3. The fuel bed burned much more uniformly throughout its depth.
4. There was less combustible ejected from the underfeed section to the clinker grinder pit.
5. Less carbon was contained in the refuse discharged to the ash pit.
6. The refuse in the clinker grinder pit ground out with less trouble due to the character of the clinker.

Mr. Clarke says that: "the tests do not indicate in any sense, the limit in temperature which can be successfully used for combustion air. There are no indications whatever of any undesirable effects on the stoker parts or of general combustion conditions which are not favorable to the higher air temperatures used. It is probable that still better results could be obtained with somewhat higher temperature than that used."

The N.E.L.A. Prime Movers Committee report for June, 1928, carries a statement by the Kansas City Power & Light Company on air heater performance as follows:

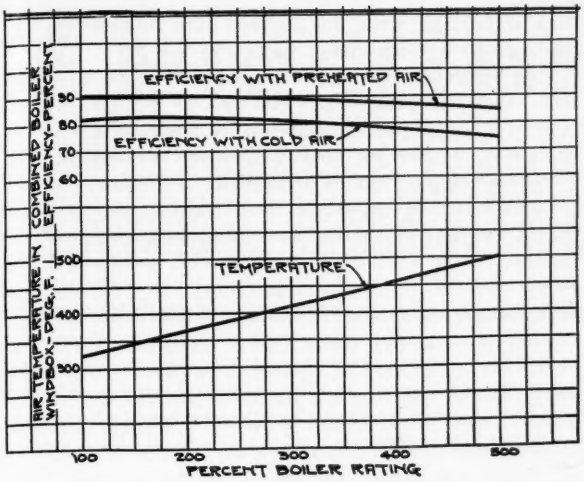


FIG. 2. IMPROVEMENT IN EFFICIENCY OF A STOKER FIRED UNIT CAUSED BY PREHEATED AIR

"Figure 1 shows a pronounced case of efficiency and capacity increase, the broken line representing a similar unit without an air heater.

"The rapid increase in ash pit loss above 220 per cent rating indicated the economical limit on the unit without the air heater, whereas with the air heater 275 per cent was obtained with about the same economy.

"The gain in efficiency is in excess of that accounted for by the B.t.u. returned to the fuel bed; the reasons for this have been expounded in the previous report and elsewhere, so will not be repeated here."

In this same bulletin there is a statement by the American Engineering Co. regarding preheated air with Taylor stokers as follows:

"Many Taylor fired plants using preheated air are already in operation and experiences at these plants show that this process not only increases efficiency by recovering heat from the waste gases but also by aiding and improving the process of combustion.

"Taylor stokered plants are operating successfully with air preheated as high as 500 deg. F. Stokers are built that are guaranteed to operate successfully on air of 600 deg. F."

Figure 2 shows the improvement in thermal efficiency of Taylor fired furnaces effected by the use of preheated air. In a book on Combustion in the Power Plant, T. A. Marsh, on page 158, says: "It is well known that heated air will greatly accelerate the reactions of combustion, thereby making combustion in the furnace more complete and reducing hydro carbon losses."

In a recently published third edition of "Finding and Stopping Waste in Modern Boiler Rooms," Jos G. Worker on page 550 gives 10 items showing the beneficial effects of preheated air with stoker firing as follows:

1. The efficiency of the modern stoker, boiler and superheater at 200 per cent boiler rating will be 83 per cent.

2. The efficiency of the modern stoker, boiler, superheater and preheater at 200 per cent boiler rating will be 90 per cent.

3. The modern stoker can be operated at 500 per cent boiler rating continuously.

4. The modern stoker can be operated to handle peaks of short duration up to 700 per cent boiler rating.

5. The CO_2 performance with preheated air will range from 12½ per cent at 250 per cent boiler rating to 16½ per cent at 350 per cent rating and above.

6. Combustible loss in refuse will be less than 0.7 per cent of 1 per cent B.t.u. in coal or 7 per cent of combustible in refuse.

7. For maximum rating, 80,000 B.t.u. can be liberated per cu. ft. of furnace volume per hour.

8. It is easier to burn coal which might otherwise smoke, entirely without smoke.

9. Elimination of continual cooling and heating of fine particles of ash by introduction of heated air in refuse, resulting in easier handling of refuse of fuel bed.

10. Preheated air in effect lengthens the stoker fuel bed by decreasing the amount of space required for drying the coal, making more effective the actual carbon burning zone."

On page 555 of this same book, Edwin B. Ricketts gives a table of typical air heater performance in central stations in both this country and abroad. This gives values for increased efficiency due to better combustion.

It is an established fact, demonstrated in both boiler room and oil refinery practice that preheated air increases furnace temperature and consequently increases the rate of radiant heat transmission to the boiler in a much greater ratio than where cold air is used. The increased heat transmission rate has the effect of reducing the flue gas temperature leaving the boiler to a point lower than it would have been had cold air been used.

In the January, 1929 issue of Combustion, page 32, preheated air in stoker operation is discussed. The following paragraph expresses quite clearly the views which most combustion engineers have regarding the effect of preheated air on combustion efficiency:

"Increased furnace temperature resulting from the use of preheated air is effective in increasing boiler efficiency provided the boiler surfaces are properly disposed to take advantage of this gain. Heat transfer by radiant heat increases approximately as the difference of the fourth powers of the furnace temperature and of the boiler tube temperature; hence increased furnace temperature resulting from the preheat in the air and from more complete combustion, leads to a large increase in the rate of radiant heat transfer and to higher boiler efficiency. High degrees of air preheat are now sought and temperatures of 300 to 500 deg. F. are being tried on stokers."

Apparently the statements made by Messrs. Foresman and Mosshart regarding the ineffectiveness of preheated air have not been substantiated by published data in books or magazines and data supporting their conclusions regarding preheated air would be of interest.

Boston, Mass. J. R. DARNELL.
Sales Engr., B. F. Sturtevant Co.

ENGINEERS, as a rule, prefer graphical rather than numerical presentation of tests or reports, because the mind is more sensitive to form as perceived by the eye than it is to large numbers.

Interesting Experiences in Repairing Generators

HERE ARE some experiences I have had in repair work; they may help somebody to save time and trouble under similar difficulties.

One of my interesting experiences was in a packing house where a direct-current generator would not build up voltage. The armature had been taken out and repaired and when it was put back into service the generator would not operate. Investigation showed that the engineer had put on a new set of brushes and had sanded them to fit the commutator perfectly. The brush holders, however, were of a type in which the brushes are fastened solidly in the holder with screws. The holders had worn enough to cause the brushes to strike the commutator only at the back corners, when the machine had started. After sanding the brushes in again, being careful to pull the sand paper only in the direction in which the armature turned, the machine picked up its load without difficulty.

At another time, some shunt-field coils for a compound-wound generator were wound and, when the coils were put in, the machine would not work. When rewinding, approximately the same amount of wire had been inserted in the new coils although but little attention had been paid to the number of turns in the coils. The generator had been connected as a short shunt—that is, the shunt lead had been connected to a compound lead for a line. When the new winding showed trouble, this short shunt was changed to a long shunt by putting the shunt lead onto the armature and compound leads. The machine then built up properly. The engineer said that before this the machine required about three minutes to build up its voltage, whereas now it takes only about one-half of a minute. Probably the machine had been over-compounded and the resistance of the compound cut out all the voltage that the armature would generate from the residual magnetism.

On another compound-wound generator that was connected short-wound, the machine ran extremely hot. When it was changed to a long shunt, the machine ran considerably cooler.

Hobart, Ind. HARRY J. ACHEE.

Diesel Operation Justifies Expert Supervision

THE ABOVE HEADING in the editorials of the August 1 issue attracted the writer's attention as he learned the truth of that maxim over 20 yr. ago. It was on the occasion of the addition of a Diesel engine to a plant that had been employing steam and water for power.

There had been rumors of plants where inexperienced help had been employed on such units and many concerns had visions of low paid engineers. The erecting engineer was an old steam man and he promptly said that the Diesel engines require about four times the repairing that a steam engine does. His instructions and injunctions were excellent and thorough so that we were able to give good service with the unit.

This type of engine was quite new in this country at that time and the design was experimental in some respects. Many concerns made the mistake of employing men who were not careful mechanics and got into such difficulties with the engines that they frequently replaced them with steam units.

Today, with the large number of plants equipped with Diesel engines, there should be plenty of good operators and no attempt should be made to save a few dollars by employing men of limited experience.

Diesel engines, made by reliable manufacturers today are so improved over those of 20 yr. ago that some of the old-time operators would find them very easy to handle. Take lubrication systems, for example, today every part of the main connections are well supplied and that means so much less wear than where the supply is uncertain; cylinders are bushed and parts made more accessible and easier to adjust. In short, the engines have passed out of the experimental stage and with proper supervision they should give satisfaction.

Cambridge, Mass. G. H. KIMBALL.

Device for Feeding Boiler Compound

FORMERLY, for boiler water treatment, we used the device shown in Fig. 1 consisting principally of a mixing tank in which tri-sodium phosphate, in powder form,

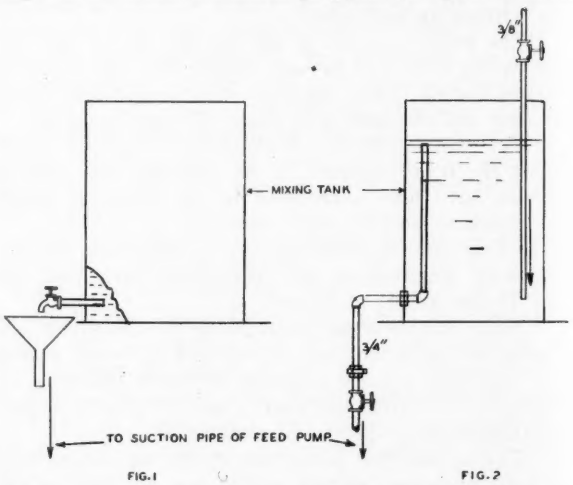


FIG. 1. ORIGINAL METHOD OF FEEDING TREATED WATER CAUSED FEED PIPE TO BECOME CLOGGED
FIG. 2. SUBMERGED FEED LINE TO TANK SETS UP AGITATION AND CAUSES COMPLETE MIXTURE

was mixed with boiler feedwater and the mixture discharged through a funnel into the pump suction line. Our practice was to put two pailfuls of the powder into the tank which was full of water and to stir the mixture. The feed was regulated by means of the valve shown. Trouble frequently occurred with this arrangement due to clogging up of the feed line.

Remodeling this device as shown in Fig. 2 overcame all difficulties. Under the new arrangement, a bag of the tri-sodium phosphate amounting to about 200 lb. is put into the tank. Mixing is accomplished by means of the ⅜-in. pipe which is connected to the discharge end of the feed pump and through which warm water passes. This agitates the water in the tank and permits nothing but dissolved material to pass through to the pumps.

Regulation of feed is accomplished by means of the ⅜-in. valve, which is usually merely "cracked" open, the amount of feed being equal exactly to the amount of water permitted to pass the ⅜-in. valve.

New York City THOMAS SHEEHAN.

Questions and Answers

Longitudinal and Girth Seam Strengths

REFERRING to an article under the above heading in the July 1 issue, while it may be well to explain this in the manner shown in an article to engineers, it may be a little difficult for young firemen who are trying to advance to an engineer's rating to see through formulas and often the writer has had to explain this same question to such men, who grasp the idea more easily from a simple explanation than by discussing figures and formulas. The following explanation may be, therefore, the means of helping somebody to see this from an entirely different angle.

In any pressure vessel, it is practically impossible to build a joint which is one hundred per cent as strong as that of the solid plate; therefore, all things being equal, a pressure vessel will rupture at the weakest point, that is, the joint. If there were no joint or if it were known that both longitudinal sides of a pressure vessel would rupture at the same time, it would be well to use the pressure, diameter, tensile strength and the two thicknesses of metal in figuring the bursting pressure; but as the joint is weaker than the solid plate, it is only necessary to figure one side or one thickness, therefore half the diameter or the radius is considered. The curvature of the shell has nothing whatsoever to do with calculating the strength of the joint, as pressures act in straight lines, so the vessel can be considered as two flat plates, the pressure acting between them and trying to separate them.

In finding the pressure exerted on any joint, it is necessary for comparison to use the same unit of length for each joint; therefore by using one inch of length on the longitudinal joint, we are considering the pressure exerted on any inch of length as shown in Fig. 1 and considering the curved surface as being flat, we find that the pressure is acting on a rectangle whose area is equal to the radius of the vessel multiplied by one inch. For example, in a 72-in. diameter vessel with 100 lb. pressure, the pressure on one inch, of longitudinal seam would equal the area of this rectangle multiplied by the unit pressure or $36 \times 1 \times 100$ equals 3600 lb. pressure.

Now, we know that the pressure on the total girth seam is equal to the area of the head multiplied by the pressure and this divided by the circumference in inches gives the pressure exerted on each inch of the girth seam. But, to show plainly that there is twice as much pressure on the longitudinal seam as on the girth seam we must refer to Fig. 2, where we have divided the head in equal spaces of one inch of girth and it will be seen plainly that we now have triangles, not rectangles, whose base is one inch and whose altitude is the radius or half the diameter of the vessel.

Now, a triangle whose base and altitude are the same as those of a rectangle, must have half the area of the rectangle. The unit pressure being equal in all directions, therefore, will certainly exert twice the pressure on a rectangle as it will on a triangle of the same dimensions and for this reason there is twice as much pressure exerted on every inch of longitudinal seam as there is on every inch of girth seam and the girth seam need be only about half the strength of the longitudinal seam.

For example, in a 72-in. diameter vessel with 100 lb. pressure, the pressure on one inch of girth seam would

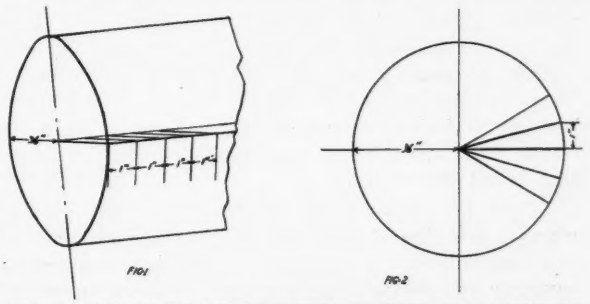


FIG. 1. PRESSURE ALONG LONGITUDINAL SEAM MAY BE REGARDED AS TAKING PLACE ON RECTANGULAR SECTIONS

FIG. 2. PRESSURE ON GIRTH SEAM MAY BE REGARDED AS BEING APPLIED TO TRIANGULAR SECTIONS

equal the area of a triangle multiplied by the unit pressure, or $(36 \div 2) \times 1 \times 100$ equals 1800 lb. pressure which is one-half the pressure exerted on the rectangle Fig. 1.

Somerset, Mass. WILLIAM H. BURTON.

Coil Spring Calculation

KINDLY LET me know how to calculate the diameter and thickness of spring, and number of coils for a compression spring such as used on a reducing valve.

A. F. S.

A. Helical springs for tension or compression are stressed in torsion. Let us assume that the mean coil diameter is D and that the diameter of the wire is d. For a cylindrical spring, the moment of the load P with regard to the cross-sectional area of the wire A is PD $\div$ 2; hence PD $\div$ 2 = (I $\div$ a) S where I $\div$ a is the torsional section modulus and S the stress in torsional shear. For a spring made of square wire, this would become $P = 0.41\ b^3S \div D$. For a spring made of round wire of a diameter, d, we have

$PD \div 2 = (\pi d^3 \div 16)\ S$ and $P = \pi d^3 S \div 8D$

Usually the pitch of the spring is 2d so that it can be compressed one-half of its free height. Therefore, having calculated the diameter of the wire, the minimum free height for any given amount of compression is easily found and the number of coils determined.

Editorial Comment

Specifications—Good and Bad

By no means the least objectionable trait of the engineer is his proclivity for specification writing. This may vary from a modest page or two up to the detailed volume affected by the municipal engineer who feels that the demands of red tape and government regulations are not met until he goes at least as far as specifying the color of molding sand to be used in the foundry.

Now, specifications are useful if properly written so as to serve as a guide and not a hindrance to the manufacturer. There are, or should be if the engineer has done the preliminary work carefully, certain local conditions that must be met to make a definite piece of equipment fit in with the entire assembly to best advantage. Such limitations and necessary legal paragraphs should be set forth clearly in the specifications so that the manufacturer can make his bid accordingly. To go further and dictate the design of the equipment beyond the desired characteristics is, however, imposing on the manufacturer and implying a detailed knowledge that is not warranted.

There are, of course, exceptions to this: for instance, where a new line of equipment not yet standardized by manufacturers comes into use or experience with certain equipment has brought out a specific weakness of certain designs. It is a surprising thing, however, that the most elaborate and detailed specifications are written about standard equipment, leading one to believe that specification writing is a game to see who can take an existing specification and add the most to it. Naturally, the older a piece of equipment is, the more discarded specifications are available and the more elaborately they can be rewritten.

To cite a specific case, not the worst by any means but quite typical, we can take that of a small Midwestern community which recently needed a 1500-kw. turbogenerator of the type turned out as a stock job by any one of a number of manufacturers much as a modern bakery turns out ginger snaps; that is, they are made carefully, well designed and of good material but have been a standard product for years.

The original specifications consisted of 24 pages of single spaced typing and an additional 15 pages giving the form in which the proposal was to be submitted. Some of the first part was of a legal nature but most of it referred to the machinery itself. Six alternates with equipment erected were asked for and the data called for with the submitted bid consisted of some 627 separate items.

On top of this, seven additional pages were issued about a week later covering such items as: "A question has been raised as to exactly what is wanted," in spite of the original 39 pages of specifications; a notation to the effect that certain piping between the pumps and condenser was to be supplied in spite of the original specifications which said, "The price shall include all appurtenances and applications necessary to make the entire work complete as herein specified; it is the intension of this contract to provide finished work and any items omitted therefrom which are clearly necessary for the completion of the work or its appurtenances shall be considered a portion of the work even though not directly specified"; and a notation regarding the size of condenser tubes desired which was to the effect that "present tubes are 1 in." and "tubes as small as 5/8 in. should not be desirable," thereby setting the limits as wide as current practice dictates and fixing the size no more definite than in the original specifications where no mention of tube size was made; and steam and power costs and hourly operation on which bids were to be evaluated, originally left out of the specifications.

Comparatively these specifications were not objectionable as to the manufacture details covered although some of those included strike one familiar with the field as odd, or rather arouse his curiosity as to why they were included.

There are a few engineers with sufficient knowledge and experience to specify manufacture details but when dealing with standard equipment, the safe thing to do is to specify the conditions to be met and deal with recognized and reliable manufacturers, leaving the details of design up to their engineers.

Water, Water Everywhere!

Man is primarily a land animal, yet it is a curious paradox that if it were not for water he could not live on land. The more one thinks of the ways in which water enters into every human activity the more he wonders whether, after all, it is not the most important chemical combination in the world.

To begin with, man himself is an aqueous solution of a few minerals. The ancient Greeks thought that the four primary substances were earth, air, water and fire. But man cannot breathe air that is perfectly dry; he must drink water or die; he finds no sustenance on the deserts of the earth and it is water, to a large extent, that enables him to control fire.

From such philosophical speculations, one proceeds to the observation that intercourse between the various continents is largely influenced by the great waters of the oceans and rivers that comprise almost three-fourths of the earth's surface.

Furthermore, it is difficult to think of an industry in which the presence or the absence of water is not the primary factor. Water is of equal importance with fuel in the operation of every steam power plant. In modern times, we need water in industrial plants not so much for furnishing power as for carrying on the processes.

Not long ago, a certain trade association, establishing a testing plant for its industry, deliberately sought to locate in a city where the natural well water supply possessed the worst natural properties for its processes.

If by use of suitable water treatment, those processes could be carried on there economically, certainly any other company in the industry, with better water, should be able to do as well as the standard plant.

It has been reported that a large organization manufacturing carbonated beverages built a million-dollar factory in a certain city without bothering to analyze the water, only to find that the flavor of its products was completely changed by the different water. Unfortunately, the change was for the worse.

Many people wonder why most rayon mills were not originally located near the usual textile centers. Water free from vegetable matter for the processes was the determining factor, provided that labor, raw materials, markets, transportation and power were nearly equal.

So we might continue indefinitely citing instances of the supreme importance of adequate water supply to every phase of human activity. The characteristics of the water itself are not so important in these days of scientific water treatment. It is the quantity that we need. By proper treatment, it is usually possible to get perfectly pure water beginning with anything. At first thought, one might think that the expense of doing this would be too high. But, in many cases, water treatment makes it possible to carry on processes that would otherwise not be possible at all, even though other factors are favorable.

No longer do we locate our industries near running streams merely because the water power will turn our wheels. We locate them near lakes, rivers or wells that will give us what we need for our processes. We can be sure of the power nowadays.

These are the sketchiest of comments on the importance of water. The subject seems endless. What have been the effects of water, through millions of centuries, on the physical earth, on the physical structure of man and on the mind of man? It is significant that among all the races of man and in all languages, their most important legends are those of a great flood or a great drought.

European and American Design

One of the byproducts of the recent World Power Conference at Berlin is an involuntary comparison of ways of doing things on two continents. For a given problem, of course, local conditions dictate the solution, based on the same general principles, so that the results may be far different in various cases. Taking this fact into account, however, Wm. M. Carpenter, writing of the Conference in the N.E.L.A. Bulletin, calls attention to the way in which European mechanical and electrical equipment seems to be designed in an attempt to secure lightness, grace, economy of materials with adequate strength. This is a point that should stimulate considerable controversy and deserves some serious thought.

It raises the question as to whether mere bulk arising from extra factors of safety necessarily makes for greatest strength and lowest cost. To be a little more technical, are you any better off in the design of a given machine, with a factor of safety (or ignorance) of 5 that you are not at all sure of, than you are with a factor of 2 that you know definitely? If you know definitely that the factor is 2, then you are certain that the structure is twice as strong as necessary.

In view of the present need of reducing the investment in power equipment per unit of capacity, this point is worth some thought, at least. Of course, the European attitude of mind, contrasted with the American, must be taken into account. In Europe there is not the demand for haste, for getting things done quickly, that there is in America. It takes time to design equipment for lightness, strength and efficiency. How does the cost of designing to save material compare with the saving?

Furthermore, what of standards of service in Europe as compared with those in the United States? We are told by engineers that service interruptions are not regarded in Europe with the same concern that they arouse in this country. We are told also that equipment is designed according to the theoretical principles with little consideration for the problems of operation, an important design factor here. Moreover, labor costs in Europe are so low that it does not cost much to manufacture equipment the design of which has been highly refined.

These comments are not offered with any idea of starting a controversy over European and American design and construction. But one of the purposes of a World Power Conference is to create an interchange of experience and it is always well occasionally to test our own performance in comparison with that of our fellows. There is little likelihood that we shall want to change our methods materially. But in these days, faced with a demand for more system capacity per dollar of investment, the power engineer cannot afford to handicap himself by ignoring the best in design and operating practice, regardless of its origin.

How Is the Coal Fired?

Considerable skepticism has always attended estimates of the percentages of coal fired in power plants by hand or stokers and in pulverized form. Of recent years not a little interest has attended the growth of pulverized coal and speculation regarding the decline of hand firing has been rife.

Accurate data regarding firing methods of coal consumed by electric public utilities are now available from reports of the Department of Interior. Current reports are too old to be of much immediate value but an accumulation of data over a period of years will be valuable in depicting trends.

In 1928 approximately 50 per cent of the total coal burned by this industry was fired by underfeed stokers. Chain grate stokers account for another third while pulverized coal trails a poor third with about a sixth. Overfeed stokers and hand firing trail far behind the other, the exact values being as follows: underfeed, 49 per cent; chain grates, 28.7 per cent; pulverized coal, 17 per cent; overfeed stokers, 3 per cent and hand firing, 2.3 per cent.

This survey includes practically all power plants with the exception of a few small ones accounting for less than 2 per cent of the total coal consumption so that the omission does not impair the representative character of the results.

MANAGEMENT and operation methods are never the same and the successful engineer cultivates the management's viewpoint.

Power Plant Engineering Developments and News

Elastic Disc Expansion Joint

EXPANSION JOINT of new design illustrated here has reeently been placed on the market. The joint consists essentially of an expansion element connecting two flanges as shown, the flanges being guided relative

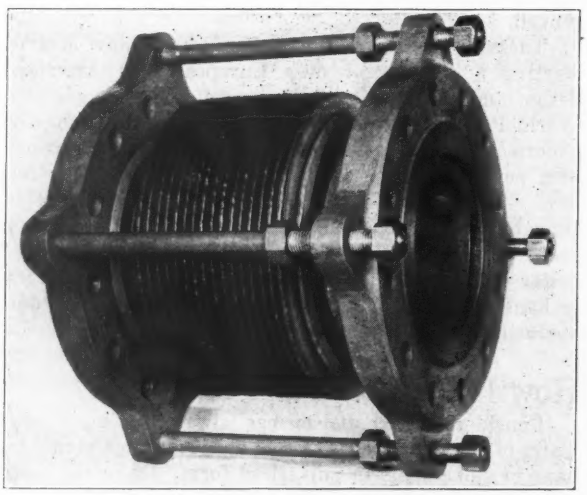


FIG. 1. TYPE A ELASTIC DISC EXPANSION JOINT, WITH PROTECTIVE CASING REMOVED

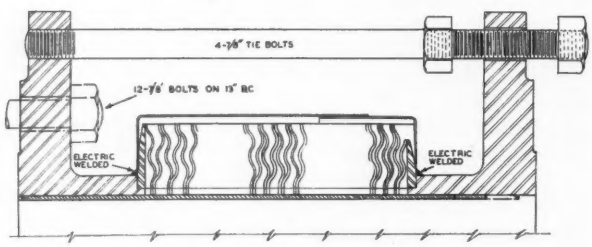


FIG. 2. CROSS-SECTION OF TYPE A JOINT

to each other to permit longitudinal but not lateral movement. It is designed so that this longitudinal movement is secured by the bending of the metal of the flexible element.

This element consists of a number of corrugated steel discs alternately welded together at inner and outer circumferences. In Type A joints, for high pressure and temperature, the end discs are provided with enlarged flanges for attaching to the flanged end pieces. Discs are pressed from plates of special crucible nickel steel, stated to have an elastic limit of 170,000 lb. per sq. in. and an ultimate strength of about 220,000 lb., combined with great toughness or resiliency.

The discs and entire assembly are welded by the atomic hydrogen welding process and a casing is placed over the element. Completed element is heat treated after welding to neutralize any local strains.

Inside the elastic element is a heavy tube, one end of which is forced into one of the flanged heads, the other end making a close sliding fit with the other movable flanged head. The object of this is to guide the movable head in a true axial line.

This joint is made by Croll-Reynolds Engineering Co., 17 John St., New York City, in three types: A for high pressure and temperature; B for pressures less than 125 lb. where the stresses are longitudinal only; C for pressures less than 125 lb. where there are considerable lateral stresses.

High-Pressure By-pass Oil Filter

NUGENT BYPASS PRESSURE Oil Filter for fuel and lubricating oils, recently developed, was designed to provide large filtering capacity for the space occupied and to have low first cost and low upkeep. It was designed so that the filtering element may be removed, cleaned and replaced quickly without breaking any pipe joints or without use of a tool. It is arranged to bypass automatically the full amount of oil to the machine, in case the attendant neglects to clean it. The filter is designed to withstand 100 lb. pressure, to be set vertically, horizontally or at an angle or immersed in a tank. Provision is made for warning the attendant when cleaning is necessary.

Figure 1 shows an installation of two filters installed

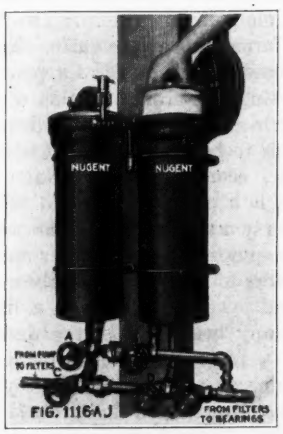


FIG. 1. ASSEMBLY OF TWO FILTERS ON LINE, ONE BEING CLEANED

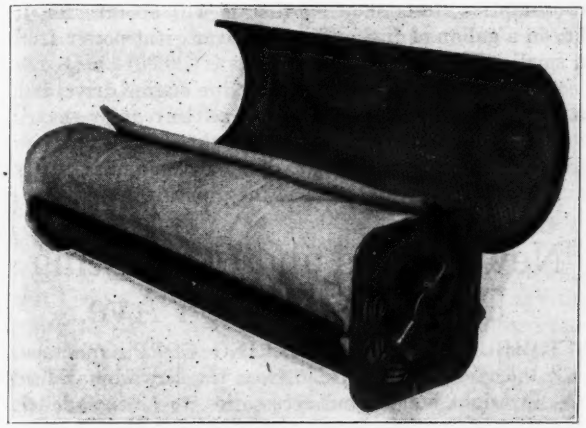


FIG. 2. FILTERING ELEMENT IN CAGE READY FOR INSERTION IN FILTER

so that one filtering element can be removed for cleaning while the other is working.

The filtering element is shown in Fig. 2. The open ends of four filtering elements are securely fastened to four projecting oil nozzles on a central distributing spool, through which the oil is forced into the bags. The elements are rolled up about this spool, with wire spacing mats between them to permit the oil to reach all the surface. The filtering element is of different grades and densities of fabric to filter oils of different viscosity.

The filters are set to bypass at 10 lb. plus the pressure in the oiling system. Filtering capacity depends largely on viscosity and temperature of oil to be filtered and density of filtering element. For heavy oil, the manufacturer recommends that heat be applied to the outside of the filter to thin the oil so it will flow freely. This heat can be applied by a steam or hot-water coil or by immersion in hot water or steam.

The filter is a product of Wm. W. Nugent & Co., 410 N. Hermitage Ave., Chicago, Ill.

Feedwater Heaters for High Pressure

HIGH-PRESSURE FEEDWATER HEATERS of new design have recently been placed on the market by Elliott Co., Jeannette, Pa., as shown in the accompanying illustrations. Increases in pressures at which such units are used as extraction feedwater heaters with modern high-pressure steam turbines have led the company to adopt new materials and improved construction to insure design performance and uninterrupted operation. One of the principal objects was to eliminate steel castings.

This new series of high-pressure heaters is designed to have all the accessibility of low-pressure cast-iron heaters and at the same time the advantages of forged steel materials. Inlet chamber and reversing chamber are of forged steel, with forged steel water nozzles welded to the inlet chamber. Water box covers and tube sheets are of rolled steel.

Staybolt construction as shown is intended to eliminate the shroud spacer around the staybolt between tube sheet and water-box cover, so that all materials will be subjected to the same temperatures and will have

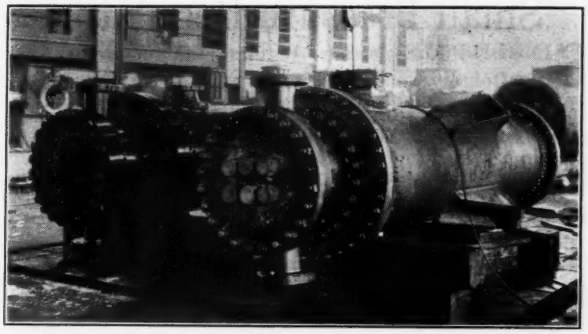


FIG. 1. EXTERIOR VIEW OF TWO OF THE NEW HIGH-PRESSURE HEATERS

the same expansion. The shroud spacer is replaced by a non-ferrous backing nut. This construction, it is stated, allows a smaller water chamber holding the high pressure and necessitates removal of a minimum number of tubes.

Use of staybolts, it is claimed, eliminates wearing of tube plates, and prevents leakage. The heater shell is of welded pipe or riveted steel, designed for a minimum number of joints and maximum accessibility of tube bundle. Removable shell head is provided to allow tube inspection. Shell and shell head flanges are rolled steel riveted to shell and shell head. The company has developed a special tube rolling tool to prevent overstressing the tubes.

Tube support plates are of rolled steel, to give a close sliding fit and thick enough for liberal bearing area. Heater tube bundle has a steel supporting frame

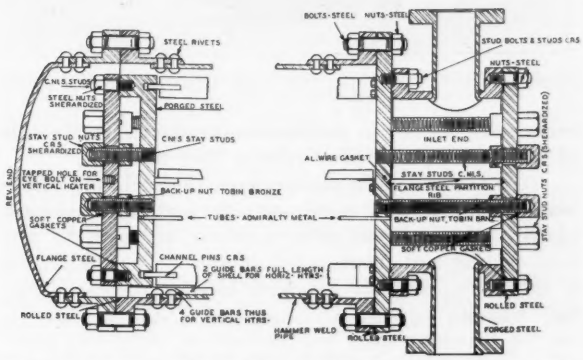


FIG. 2. LEFT—REVERSING CHAMBER OF ALL-STEEL HIGH-PRESSURE HEATER. RIGHT—WATER INLET AND OUTLET CHAMBER OF HEATER

fixed to the inlet tube sheet, with a sliding connection in the floating head to permit free movement of the floating head and to provide rigidity in the tube bundle. Baffles are set in front of all steam and condensate return connections to prevent direct impingement of vapors on the tubes.

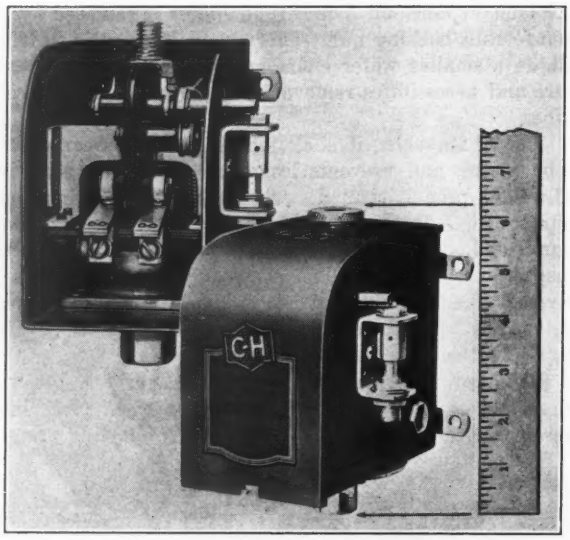
These heaters can be arranged for either vertical or horizontal mountings. The general design is likewise available for moderate and low pressures.

IN INTERNAL COMBUSTION engines, the loss due to waste heat generally falls between 25 and 40 per cent of the heat supplied as fuel.

Small Pressure Regulator

SINGLE-POLE pressure regulator of new design, exceptionally small in size, is announced by Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wis. This new device, designated as Bulletin 10,006, is for use as a starting switch for motors up to one horsepower, 230 v., a.c. or d.c., or as a pilot switch in the control circuit of automatic starters for larger motors. The regulator closes the circuit at low pressure and opens the circuit at high pressure. It can be adjusted to open the circuit at any pressure from 30 to 200 lb.

Applications range over a wide field; it is designed to be used for maintaining pressure on systems containing water, air, gas and other similar fluids. For air compressor service, a small unloader device at the side of the case is provided to remove back pressure.



NEW PRESSURE REGULATOR FOR MOTORS UP TO 1 HP.

To withstand moist atmospheres, the enclosing case is black japanned and metal working parts are cadmium plated. Double-break silver contacts are used to prevent pitting and insure good contact. The diaphragm is of rubber. Conduit knockout holes in the case facilitate wiring.

Gasoline Engine Drive for Power Boy

THE OSTER MANUFACTURING CO., Cleveland, Ohio, has just announced that its No. 412 Power Boy is now available with a gasoline engine drive. It is claimed that the new gas-engine Power Boy combination is just as portable as the regular Power Boy with electric motor drive, the weight being only a few pounds more. The gasoline motor is a 1-hp., single-cylinder, air-cooled Briggs & Stratton motor. It is the regular 4-cycle type and has a 2¼-in. bore and 2¼-in. stroke. It is equipped with a high-tension magneto and uses standard motorcycle spark plugs that can be obtained at practically any garage or service station. An easily operated hand starter is standard equipment and an Eclipse motor cycle clutch is provided. The motor is connected to the Power Boy with a roller chain. The manufacturer claims that the motor is exceptionally economical in fuel consumption, tests showing that it will operate for 10 hr. on a gallon of fuel and will deliver great power from a small amount of gasoline.

The new Power Boy with gasoline engine drive, it is stated, will operate equally as fast as the regular electric universal motor-driven model, will thread and cut pipe up to 2 in. without the auxiliary drive and with the auxiliary drive it can be used for pipe up to 4 in.

New Boilers and Generating Units for Hudson Ave.

COMBUSTION ENGINEERING CORP. announces the receipt of contract from the Brooklyn Edison Co. for eight boilers and accessories, to be installed in the Hudson Avenue Generating Station. This contract amounts to over $2,000,000 and is believed to be the largest contract for boiler equipment ever placed in this country. In addition to the boilers, the contract includes complete water-cooled furnaces, boiler settings and steel work, and economizers, all of which equipment is to be designed, manufactured and installed by Combustion Engineering Corp.

The boilers are of the Combustion Engineering bent-tube type, containing 24,450 sq. ft. of heating surface per boiler and equipped with Elesco superheaters. The design pressure is 500 lb. per sq. in. with an operating pressure of 440 lb. at the superheater outlet. The four walls of each furnace are of C-E fin tube construction, with a total of 3350 sq. ft. of heating surface per unit. The furnace volume is 17,300 cu. ft. Each unit is equipped with a C-E fin tube, return bend economizer.

All eight units are of identical design and are arranged for stoker firing. Each unit is designed for a maximum steam production of 530,000 lb. per hr. Four units are scheduled to be in operation by August, 1931, and the remaining four by January, 1932.

Two turbine generators that will set several records for capacity and size are being constructed at the Schenectady works of the General Electric Co. for installation in the Hudson Avenue station. One will be installed in September, 1931, and the other in April, 1932.

Each turbine will be of tandem-compound construction, with double flow in the low-pressure cylinder, and will drive a single generator of 160,000 kw. capacity at 0.8 power factor, with a maximum output of 200,000 kv-a. The unit is, therefore, the largest single-shaft machine operating at 1800 r.p.m. Without auxiliaries or attachments, the combined weight of each turbine and generator will be more than 1000 t. The turbines are designed for steam conditions of 400 lb. gage pressure, 730 deg. total temperature, and one inch absolute back pressure. Provision is made for bleeding steam at two stages for heating the feedwater to a temperature of 270 deg. F. The compactness of the unit is shown by the fact that an output of almost 100 kv-a. is obtained per square foot of floor area.

Steam is admitted to the turbine through five control valves which open in sequence, therefore resulting in a flat load curve and high economy at partial loads, it is stated. The turbine is designed to operate from half to full load with a change in efficiency of less than two per cent.

The generator that will be driven by this turbine is stated to be the largest single generator in the world. Rated at 160,000 kw., 16,500 v. and 7000 amp., it operates at 1800 r.p.m. As it is an 0.8-power factor machine, the full load output of 200,000 kv-a. will be considerably greater than the output of the 160,000-kw., 160,000-kv-a. generator now operating in the East River station of the New York Edison Co.

Cooling air will be forced through the generators by four motor-driven blowers enclosed in a separate structure on top of the generator stator. All four blowers will force 220,000 cu. ft. of air per minute through the generator; at light loads, less cooling air is required and some of the blowers may be shut down. The losses in the generator which appear as heat in the circulating air will be recovered by passing the circulating air through surface air coolers, through which the condensate will be circulated. This condensate will be used as feedwater for the boilers. The air coolers are placed above the turbine room floor, two on each side of and integral with the generator. Auxiliary coolers will be installed for use when necessary, employing sea water as a cooling medium.

The Hudson Avenue station once contained the largest single-shaft generator and when the new units are installed, it will have still greater distinction for it will then contain two duplicate generators which are the largest single-shaft machines in the world.

Commercial Stocks of Coal

COMMERCIAL STOCKS of bituminous coal used largely for industrial purposes amounted to 32,200,000 t. on July 1, 1930, according to the quarterly survey just completed by the United States Bureau of Mines, Department of Commerce. In comparison with the amount on hand at the beginning of the previous quarter this is a decrease of 900,000 t. and it is also 900,000 t. less than the quantity in storage on the same date last year.

Exports during the second quarter of 1930 averaged 322,000 t. a week as against 342,000 t. during the same period last year. The weekly rate of consumption within the United States during the second quarter amounted to 7,614,000 t. as compared with 10,432,000 t. in the previous quarter. In comparison with the same period last year, the rate of home consumption plus exports shows a decrease of 1,057,000 t. per week, or 11.8 per cent.

In addition to the stocks in the hands of consumers, there was 7,883,000 t. of bituminous coal on hand on the docks of Lake Superior and Lake Michigan on July 1, as compared with 3,977,000 t. on April 1.

Stock of anthracite in retail yards on July 1 show the usual seasonal increase over the amount in storage on April 1, but are slightly less in terms of days' supply than on the corresponding date of last year.

T. M. ELLIS, Rockford, Ill., utility magnate, has sold the Beloit, Wis., Traction Co., which includes electricity, gas and water service in Beloit, to the Wisconsin Power & Light Co. for $100,000. The new owners will discontinue electric street car service at once and place motor buses over the routes but have announced that there will be no change in the other utility service rates.

News Notes

ANNOUNCEMENT is made that the National Power Show will be held in New York from Dec. 2 to 7, 1930.

NEW AMERICAN STANDARD for symbols for photometry and illumination has just been adopted by the American Standards Association, 29 West 39th St., New York. The new standard is a modification of the American Standard for Illuminating Engineering Nomenclature and Photometric Standards adopted in 1925. A national standard for navigational and topographical symbols has also been approved as American Tentative Standard by the American Standards Association.

BECAUSE OF THE constantly increasing use of brass pipe in plumbing and heating installations, The Borden Co., Warren, Ohio, announces that it will now carry in stock dies for all sizes of Beaver tools, specially ground for threading brass pipe. For easy identification, these dies will be copper plated and stamped "For Brass Pipe." No extra charge will be made for these special dies.

ON SEPTEMBER 1, Barrett-Cravens Co. will move into its new plant at 101 West 87th Street, Chicago, Ill. This move places Barrett-Cravens Co. under the same roof with its two affiliated companies, the Walker Vehicle Co. and the Automatic Transportation Co.

CHICAGO PUMP Co. announces the addition of H. G. Ragan to its list of representatives. Mr. Ragan has offices in the Brandeis Theatre Bldg., Omaha, Neb.

ANNOUNCEMENT is made by the Pickering Governor Co. of Portland, Conn., of the erection of a new building which will be devoted exclusively to its research and testing department.

CHARLES C. PHELPS, 11 Park Place, New York City, has been appointed sales agent for Metropolitan New York and Northern New Jersey, by the Leavitt Machine Co., Orange, Mass.

LINK-BELT CO., Pacific Division, has just moved into its new manufacturing plant and office, located at Paul Avenue near Bayshore Highway, San Francisco, California.

HUMPHREY J. KIELY, vice-president, Link-Belt Co., Chicago, Ill., in charge of the export division, announces the appointment of William Piez, brother of Charles Piez, chairman of the company, as European correspondent. He took up his duties for the Link-Belt Co. on January 1. Mr. Piez' duties will keep him traveling the greater portion of the time, but he can be reached in care of Hotel Lutetia, 43 Boulevard Raspail, Paris (6E), France.

BROWN INSTRUMENT Co. announces that George W. W. Cornman, treasurer and manager of the service department of the company, will retire from business, effective August 8, 1930. The service department will be in charge of R. C. Kennan as manager and E. T. Nahill as field supervisor.

Mr. Cornman has been associated with the instrument business for 35 yr., formerly being secretary and treasurer of the Keystone Electrical Instrument Company. When that organization was absorbed by The Brown Instrument Co., he became treasurer and a director of the present organization and was the active head of the service department, which was built up under his guidance.

PITTSBURGH VALVE, FOUNDRY AND CONSTRUCTION Co., Pittsburgh, Pa., announces the appointment of J. F. (Fabe) Hanst, as engineer and sales representative, Oil and Gas Division. Mr. Hanst has served as engineer and branch manager for the Ingersoll-Rand Co. for the past 12 yr.

QUIGLEY FURNACE SPECIALTIES Co., 56 West 45th St., New York, announces a change in the name of the company to Quigley Company, Inc., the address remaining the same.

FIVE MORE of the world's largest hydroelectric generators are to be added by the Union of Socialist Soviet Republics to the four already under construction in America for the Dnieper River development at Kichkas, near Zaporozhe, in the Ukraine. The first four generators are being built by the Schenectady works of the General Electric Co. and the fifth will also be entirely constructed there. The remaining four will be manufactured jointly at Schenectady and in the U. S. S. R., with assembly of the units over there.

The generators, rated at 77,500 kv-a. each, are the largest waterwheel-driven generators of any type ever built; the next largest, those at Niagara Falls, are rated 65,000 kv-a. each. The Dnieper River units will supply power to Dnepropetrovsk and the southern part of the U. S. S. R.

At the same time the Schenectady works of the General Electric Company is constructing the generators, the Pittsfield, Mass., works is building twenty-one 26,000 kv-a. transformers, and the Philadelphia works the switchgear equipment for six units.

The first generator is scheduled for shipment next April.

The nine water turbines, to operate under a head of 123 feet, are being supplied by the Newport News Shipbuilding and Dry Dock Co. Hugh L. Cooper and Co., New York, are the consulting engineers on the construction of the dam and power station.

MAYER & OSWALD, INC., 332 South La Salle St., Chicago, Ill., has been appointed exclusive representative in the Chicago territory for Babcock & Wilcox refractory products.

UNDER THE DIRECTION of R. L. Griscom, local manager, the Natchez crew of the Mississippi Power and Light Co. has successfully laid a new submarine cable across the Mississippi river from Natchez to Vidalia. The cable will supply Vidalia with electricity for light and power from the Natchez plant of the company. Although the cable is considerably larger than any that has been laid across the river at any point between New Orleans and Memphis and weighs 47,000 lb., it was laid in remarkably short time.

PRAT-DANIEL CORP. announces the appointment of C. B. McBride as a member of the sales department of its main office in New York City.

JAMES S. FENTON has been promoted to the position of sales engineer of the New York Office of the Reliance Electric & Engineering Co., Cleveland, Ohio.

I. W. TURNER of White Plains, N. Y., has been appointed to the New York sales office of Pittsburgh Valve, Foundry & Construction Co., Pittsburgh, Pa., of which Ray B. Felker is manager. Mr. Turner was formerly with the Ingersoll-Rand Co.'s New York sales office.

W. W. PATRICK, a director of The Foxboro Co., Foxboro, Mass., died suddenly, July 11, of pneumonia. He had been associated with the founders of The Foxboro Co. since 1899. In 1908, he became New York District Sales Manager and held that post for 22 yr. Mr. Patrick was also a prominent figure in the Association of Scientific Apparatus Makers of America. He was a director of the Association and Chairman of the Industrial Instrument section.

ACCORDING to a recent announcement, the merger between Pacific Gas and Electric Co. and Great Western Power Co., both of San Francisco, Cal., has been completed and the personnel of the latter has been absorbed by the former. San Joaquin Light & Power Corp., Fresno, Cal., has become a part of the Pacific service system, retains its individual identity, and few changes in personnel are contemplated. A. Emory Wishon, former vice-president and general manager of San Joaquin and Great Western companies, has become president of San Joaquin and vice-president and assistant general manager of Pacific Gas & Electric Co.

MATTHEW S. SLOAN, president of the New York Edison Co., was elected a director and member of the finance committee of the Chrysler Corp. to succeed the late Nicholas F. Brady at a recent meeting of the Board of Directors. In addition to being president of the New York Edison Co., Mr. Sloan is president of four other companies in the New York City district and was formerly president of the National Electric Light Association.

NEW KIND OF WELDED PIPE has been made available to pipe users with the placing in operation of Republic Steel Corp.'s new plant devoted to the making of electric weld pipe. An experimental mill making only small sizes has been in production for almost a year with the result that over 2000 mi. of pipe were placed in service. A completely equipped new plant has now been built for making sizes from 4½ to 16 in. in diameter.

BOSTON OFFICE of the Reliance Electric & Engineering Co., Cleveland, Ohio has moved from 80 Federal St. to new quarters at 89 Broad St. R. H. Smith will continue as district manager of this territory.

C. E. STEPHENS, vice-president, Westinghouse Electric and Manufacturing Co., has announced the appointment of T. R. Langan as assistant Northeastern District manager of the Westinghouse organization. Mr. Langan has been with the Westinghouse company for more than 20 yr. Starting as an apprentice in the engineering department, he advanced through the construction, service and sales departments of the company to the office of manager of the transportation division of the Northeastern District, which office he held at the time of his promotion. He has been identified with the major high-voltage a.c. railroad electrifications in the United States and when the New York, New Haven & Hartford Railroad system was electrified, Mr. Langan acted in a supervisory capacity on this installation for seven years. Before coming to the New York Office, Mr. Langan served the Westinghouse company in Philadelphia, Baltimore, Buffalo and was manager of the Syracuse office. He will make his headquarters at New York and will continue to function as manager of the transportation division of the Northeastern District.

WOOD INDUSTRIES DIVISION, A. S. M. E., will hold its 5th annual national meeting this fall in New York City, Oct. 16 and 17. C. L. Babcock, secretary of the division, announces that the program will consist of four technical sessions, a morning inspection trip and a dinner on the evening of Oct. 17. Further details may be obtained from the office of the A. S. M. E., 29 West 39th St., New York.

CHARLES FRANCIS HILL, chief engineer for W. F. Schrafft & Sons Corp., Boston, Mass., died suddenly on Aug. 4th while at work in the power plant of the company. He had been in the employ of this company for the past 20 yr. and had been its chief engineer for the last 12 yr. He was born in Georgetown, Mass., 55 yr. ago and was educated in the grammar and high schools there, later taking a business course in Bryant & Stratton's in Boston. Some time later he took up steam engineering and without attending any of the schools teaching the subject, worked and studied until he obtained a first class engineer's license in Massachusetts. He was a Spanish War Veteran, Odd Fellow and Mason, and since the organization of the National Association of Practical Refrigerating Engineers, he has been its secretary.

Books and Catalogs

STRENGTH OF MATERIALS, Parts I and II. By S. Timoshenko. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y.; size, 6 by 9-in.; cloth bound. Part I, 362 pages; price, $3.50; Part II, 325 pages; price, $4.50.

A very complete and thorough treatment of the strength of materials and modern design by an outstanding authority in the field. The book is divided into two parts, the first, covering elementary theory and problems, being intended to cover the usual strength of material courses as given in engineering schools, the second part, covering advanced theory and problems, being intended for graduate students and research engineers.

In the first volume, the mathematical treatment and derivations have been simplified so as to bring it within the mathematical knowledge of the average student, but a knowledge of integral calculus is necessary if the book is studied as a textbook. The second part for advanced students is divided into three parts, the first relating primarily to structural engineering, the second to machine design and the third to the material testing laboratory.

MECHANICAL ENGINEER'S HANDBOOK. Lionel S. Marks, Editor-in-Chief. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York City; size, 4½ by 7 in.; flexible cloth, third edition, total issue 103,500; 2264 pages; price, $7.00.

Following the purpose of this handbook to supply the mechanical engineer with the theory and data necessary to keep him abreast of current practice, theoretical discussions have been strengthened in this edition and a new section added on the important subject of vibration. Standards and practice have been brought up to 1930 and physical data have been revised to incorporate best current values. Considerable developments in special fields such as welding, have resulted in corresponding expansions in the discussion of those fields.

New subjects such as industrial combustion furnaces, electric furnaces and high and low temperature carbonization of coal have been added, necessitating the addition of 270 pages and the larger contributions have been subdivided into a number of smaller sections.

Increasing specialization in mechanical engineering is reflected in the increase in contributors which now number 77. Revision of some sections has been made through the services of groups of engineers connected with large engineering corporations.

SAFETY MEETINGS, No. 8 of the bulletins on Industrial Safety, contains a discussion of methods of stimulating interest through meetings. It is issued by Policyholders Service Bureau, Metropolitan Life Insurance Co., New York.

SIMPLEX BOILER FEED METER, its advantages, uses and distinctive features, with table of capacities, are discussed in a recent bulletin by Simplex Valve & Meter Co., 68th and Upland St., Philadelphia, Pa.

RESISTANCE THERMOMETERS are described and illustrated in a recent 30-page bulletin, No. 80, by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. This is a revised edition of a previous bulletin. It discusses in detail thermometers for recording, controlling and indicating temperatures. Considerable space is devoted to heating and ventilating applications, refrigeration and chemical uses and gas making and other comparatively low-temperature applications.

ENTIRE LINE of Barber-Greene materials handling machinery has been put into a single book, The Barber-Greene Line--a 32-page catalog. A page devoted to each machine contains a large posed photograph, a brief description, and general specifications and features. The catalog is published by Barber-Greene Co., Aurora, Ill.

C-E Fin-tube Economizer is described in a new 12-page well-illustrated bulletin by Combustion Engineering Corp., 200 Madison Ave., New York. This equipment was described in detail in the August 1, 1930, issue of Power Plant Engineering.

Stringalite Safety Lighting Cable for underground and outdoor illumination is described in Bulletin No. 100-A by Sullivan Machinery Co., 400 No. Michigan Ave., Chicago, Ill.

Parker Triple Tube Couplings are described and illustrated in recent bulletins issued by Parker Appliance Co., 10, 320 Berea Road, Cleveland, Ohio.

Sullivan Rock Drills, type L-8 rotators, dry and water types for general rock excavation purposes in mines, quarries and construction work, are described and illustrated in Bulletin 87-C by Sullivan Machinery Co., 400 No. Michigan Ave., Chicago, Ill.

Burke Arc Welders, high cycle motor generator sets for use with high cycle tools and Burke S and SV induction motors are discussed in three recent bulletins by Burke Electric Co., Erie, Pa.

Farval Duoline heavy duty centralized system of lubrication is described and its applications illustrated in a recent 12-page bulletin published by Lubrication Devices, Inc., Battle Creek, Mich. Details of the equipment are shown by colored drawings and photographs.

Burning of Liquid and Gaseous Fuels is the title of Publication No. 064, just issued by Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York. This report includes data on: physical characteristics of liquid and gaseous fuels, utilization methods, combustion requirements, types of burners, maintenance of equipment, comparative test results using gas and liquid fuels in the same furnace.

Sectional Cast-Iron Storage Bunkers for storing ash, coal, coke, sand and other corrosive or abrasive materials are described in a recent bulletin by Treadwell Engineering Co., Halm Division, Easton, Pa.

Type XCB-2 air compressor of improved design is described by Ingersoll-Rand Co., 11 Broadway, New York, in a recent bulletin.

Condensing Equipment is the title of Publication 069 just issued by Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York. Tables showing characteristics of latest condenser illustrations are included and indicate an increased use of single-pass condensers for large capacity. Several condensers with tubes rolled at both ends are in satisfactory operation, some with one floating head and some with both heads fixed. Satisfactory results for specific cases are reported for the use of chlorine in circulating water to keep condenser heat transfer rate up to normal. Seven-eighth-inch tubes are being used more frequently. Recent design of turbines and condensers requires less circulating water per kilowatt of capacity. Heat transfer tests show excellent performance for recent designs.

New Multiple and Red Head lift trucks are described and illustrated in Bulletin No. 123 now being issued by Barret-Cravens Co., State and 87th St., Chicago, Ill.

Borne's Universal Compressor for oil and grease and universal lubricators for industrial equipment are described in two recent bulletins by Borne Scrymser Co., 17 Battery Place, New York City.

Reeves Electric Automatic Control is described and illustrated in detail by Reeves Pulley Co., Columbus, Ind., in a recent 12-page booklet.

Report on effect of length of thread exposure upon static tensile strength and energy to rupture of standard V and Dardelet thread and nut connection, made for Dardelet Threadlock Corp., 120 Broadway, New York, has just been issued as Report No. 2207 by the testing laboratories, Department of Civil Engineering, Columbia University, New York. Another report for the same company, No. 2162, deals with comparative shock resistance of standard V thread and nut connections and Dardelet thread and nut connections.

Two Reports on supplies and storeroom subjects have just been issued by Purchasing and Storeroom Committee, Accounting National Section, National Electric Light Association, 420 Lexington Ave., New York. Publication No. 077 is A Uniform Classification for Material and Supplies. Need of strict control over expenditures for material and supplies is emphasized and the problems of stock control are discussed. Classification system of control and its value to executive officers, purchasing agent and storekeeper is described. Three major divisions of material and supplies stock; namely, I, Fuel, II, Operation, Maintenance and Construction Materials and III, Merchandising and Jobbing Revenue Materials, are outlined and sub-divided. Use of material classification card and a class control record are described in detail. Publication of No. 076, Miscellaneous Purchasing and Storeroom Subjects includes pictures of 22 interesting developments of noteworthy storeroom equipment and methods, describes a combination salvage and heating furnace, unit piling, expense distribution and related subjects.

Enduro KA 2 Steel, a new metal for modern day uses, is described and illustrated in an attractive, well-illustrated bulletin just issued by Central Alloy Steel Co., Massillon, Ohio, Ludlum Steel Co., Watervliet, N. Y., Babcock & Wilcox Tube Co., New York. This metal is an alloy of chromium, nickel and iron, is claimed to be non-corrosive, stronger than carbon steel and easily workable. The bulletin discusses its characteristics and shows the various types of equipment for which it is used.

National Continuous Blowdown and heat reclaimer is described in a recent 8-page bulletin, illustrated in colors, by National Aluminate Corp., 6216 West 66th Place, Chicago, Ill. Principles of Blowdown are discussed, tables and charts show blowdown conditions and the equipment for continuous blowdown is described and illustrated in detail.

Chromalox Electric Heating Units, electric strip heaters for many industrial applications are described in a recent loose-leaf bulletin by Edwin L. Wiegand Co., 7500 Thomas Boulevard, Pittsburgh, Pa.

In a recent illustrated bulletin, No. 7520, the de Florez remote manual control system for valves, is described in detail by the Brown Instrument Co., Philadelphia, Pa. Complete details of this system were given in the July 1, 1930, issue of Power Plant Engineering.

Detroit Single Retort Stokers are described in a new bulletin illustrating the double control of the feed of coal and its distribution in the furnace, methods of distributing air to fuel bed, automatic regulation with both steam engine and variable speed motor drive and other features. Charts and records of fuel savings and other operating economies are shown, as well as blueprints illustrating method of application of these stokers to many different types of boilers. The bulletin is published by the Detroit Stoker Co., 1224 General Motors Bldg., Detroit, Mich.

Hahn Steam-jet Conveyors for handling ash, soot, furnace-slag, coke and other abrasive materials are described in detail in a well-illustrated 30-page bulletin, No. 100, issued by Treadwell Engineering Co., Hahn Division, Easton, Pa.

Oil Refinery Equipment, including high-temperature recirculating fans, air preheaters, high-pressure propellor fans, oil economizers, turbines, engines, motors and mechanical draft fans, are described and illustrated in bulletin No. 375 by B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Boylston Steam Specialties of all types are discussed in detail by Boylston Steam Specialty Co., 122 W. Illinois St., Chicago, Ill., in its new general catalog No. 17. Necessity for strainers is discussed first, showing some of the foreign materials they keep out of equipment. Detailed description of various pressure regulators is given, with data on correct and incorrect methods of connecting them and on use of the condensation accumulator. Steam traps, pump governors, grease extractors and exhaust heads are described. Tables give sizes, dimensions and prices.

Capacity Charts for Fisher Specialties is the title of a bulletin just issued by The Fisher Governor Co., Marshalltown, Iowa. This presents alinement charts worked out by the company's research engineers showing relations between capacity, pressure, size of valve, specific gravity of gas and so on, designed for determining capacity of various Fisher specialties for air or gas. Tables and instructions are given for using valve travel coefficients. Four charts are shown for the following conditions: No. 1, standard body construction; No. 2, streamline body construction; No. 3, composition disc valve body construction; No. 4, vapor collecting valve body construction. Capacity chart is also given for determining sizes of all Fisher steam reducing valves.

Stoker Equipment and Furnaces are described in Publication No. 068 just issued by Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York. Recent installations and improvements in stoker furnace design, water walls, economizers and air heaters are explained and illustrated. The report also includes: report of boiler tests giving results obtained with stokers and water walls; maintenance costs of stokers and water walls; data on corrosion of air heaters; descriptions of cinder catcher installations. Increasing use of vane control induced draft fans is noted.

Power Plant Construction News

Ala., Fulton—The Scott Lumber Co., Fulton, is said to be planning the installation of electric power equipment in connection with proposed rebuilding of saw mill and lumber plant, recently destroyed by fire, with loss reported over $200,000.

Ark., Jasper—The Ozark Reduction Co., care of Gordon N. Peavey, Little Rock, Ark., president, is reported planning a hydroelectric generating plant on the Buffalo River, vicinity of Jasper, to develop a total output of close to 500,000 hp., entire project to cost over $1,000,000, with transmission system. Application for permission has been made to the Arkansas Railroad Commission.

Ark., Marked Tree—The Tschudy Lumber Co. is said to be planning the installation of electric power equipment in connection with proposed rebuilding of plant, recently destroyed by fire, with entire loss reported over $100,000.

Ark., Paragold—The City Council has called a special election on Sept. 21, to approve a bond issue of $125,000, the fund to be used for a proposed municipal electric light and power plant. The W. A. Fuller Co., 2916 Shenandoah Avenue, St. Louis, Mo., is engineer.

Calif., Blythe—The Southern Sierras Power Co., Riverside, plans construction of a transmission line from Calipatria to Blythe, with a power substation at last noted place, entire project reported to cost $375,000.

Calif., Los Angeles—The Los Angeles Can Co., 3852 Union Pacific Avenue, plans installation of electric power equipment in proposed new plant addition at location noted, entire project to cost more than $150,000. Francisco & Jacobus, Pershing Square Building, Los Angeles, are engineers.

Calif., Modesto—The Board of County Supervisors, Court House, has plans maturing for a new power house at the local Stanislaus County Hospital, estimated to cost about $35,000, with equipment. Russell G. De Lappe, 1710 Franklin Street, Oakland, Calif., is architect.

Calif., Salinas—The Inter-Continental Rubber Co., care of G. H. Carnahan, Salinas, president, plans installation of electric power equipment in proposed new local rubber mill, entire project to cost more than $125,000.

Calif., Torrance—The General Petroleum Corporation, 310 Sansome Street, San Francisco, Calif., plans installation of electric power equipment in proposed new oil refinery at Torrance, entire project reported to cost about $10,000,000. It is proposed to build a boiler plant.

Colo., Paonia—The Oliver Power Co. has approved final plans for a new power plant and transmission line to cost about $250,000, to be used in connection with coal-mining operations of the Oliver Mining Co., a subsidiary organization.

Fla., St. Petersburg—The Florida Food Corporation, St. Petersburg, Charles N. Harvey, in charge, is said to be planning a one-story cold storage and refrigerating plant on local water front, to cost about $45,000, with equipment.

Ga., Augusta—The Crystal Ice Corporation, 1050 Ponce de Leon Avenue, N. E., Atlanta, Ga., is said to have plans under way for a one-story ice-manufacturing plant on Twiggs Street, near Ninth Street, Augusta, to cost about $70,000, with equipment.

Ga., Eastman—Fred R. Bennett, Eastman, and associates are planning the early construction of a cold storage and refrigerating plant to cost about $35,000.

Ill., Paris—The Cummins Car & Coach Co. is said to be planning early rebuilding of portion of boiler house recently destroyed by fire, with loss reported at close to $15,000, including equipment.

Ind., Angola—The Board of Trustees, Tri-State College, has authorized the immediate construction of a new power house at the institution, one-story, 70x80 ft., reported to cost over $40,000, with equipment.

Ind., Evansville—The Board of Water Works has engaged Black & Veatch, Mutual Building, Kansas City, Mo., consulting engineer, to prepare plans for extensions and improvements in filtration plant for municipal waterworks. Estimates of cost will soon be made.

Ind., Indianapolis—The Coco Cola Bottling Co., 858 Massachusetts Avenue, plans installation of electric power equipment in proposed new two-story bottling plant, reported to cost close to $100,000. Bubush & Hunter, Architects' & Builders' Building, are architects.

Iowa, Grundy Center—The Northwestern Light & Power Co., Cedar Rapids, Iowa, is reported planning a new power plant in the vicinity of Grundy Center to cost about $50,000, with equipment.

Kans., Kansas City—The Board of Public Utilities has plans nearing completion for extensions and improvements in municipal electric light and power plant, including installation of coal and ash-handling machinery, etc. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Mass., Attleboro—L. G. Balfour & Co., Attleboro, are said to be planning a one-story power house for industrial service at local jewelry factory to cost about $45,000.

Mass., Cambridge—A. H. Hess & Co., Inc. is said to be planning installation of electric power equipment, in connection with proposed rebuilding of flower pot and clay products manufacturing plant, recently destroyed by fire, with loss reported in excess of $100,000.

Mass., Everett—The Mystic Iron Works, 250 Stuart Street, Boston, is said to have plans for a one-story boiler plant at local works on Dexter Street, to cost about $45,000, with equipment.

Mass., East Longmeadow—The Central Massachusetts Electric Co., Palmer, Mass., is said to have plans under way for a one-story power substation at East Longmeadow, reported to cost about $60,000.

Mich., Calumet—The Seneca Copper Co., plans the installation of electric-operated pumping machinery and auxiliary equipment, in connection with an expansion project at local mining properties.

Mich., Manistique—The Inland Lime & Stone Co. is considering the construction of a one-story power plant at local works to cost over $60,000, with equipment.

Mo., Independence—The City Council has plans maturing for extensions and improvement in municipal electric light and power plant, including installation of boilers, stokers, ash-handling and other equipment, entire project to cost about $110,000. Black & Veatch, Mutual Building, Kansas City, Mo., are consulting engineers.

N. D., Williston—The Common Council has preliminary plans under way for a water purification plant and will soon ing Co., Interstate Building, Kansas City, Mo., is consulting engineer.

N. J., Bound Brook—The George A. Just Co., 395 Lexingtin Avenue, New York, plans installation of electric power equipment in proposed new structural steel fabricating plant on tract of land acquired at Bound Brook, entire project to cost close to $100,000.

N. J., Newark—The Industrial Terminal Co., 50 Church Street, New York, an interest of the Erie Railroad Co., same address, plans installation of electric power equipment; elevating, conveying and other mechanical-handling equipment at proposed new eight-story freight terminal at Ogden and Gouveneur Streets, Newark, entire project reported to cost more than $1,500,000. Company engineering department is in charge.

Ore., Portland—The F. C. Stettler Mfg. Co., 300 Oregon Street, plans installation of electric power equipment in connection with proposed rebuilding of paper box manufacturing plant, recently destroyed by fire with loss reported in excess of $500,000.

Pa., Philadelphia—The Atlantic Refining Co., 260 South Broad Street, plans rebuilding of pumping plant on Penrose Avenue, near Gallows Lane, recently destroyed by fire; an official estimate of loss has not been announced.

Wash., Everett—The Great Northern Power Co., care of the Monarch Engineering & Construction Co., 1105 Second Avenue, Seattle, is said to have plans maturing for a proposed hydroelectric power development in the vicinity of Everett, entire project reported to cost more than $3,000,000, with transmission system. The engineering company noted will be in charge of project.